State Geological Survey of Cal.

With compliments of

B. A. Skidmore

STATISTICS

OF

MINES AND MINING

IN THE STATES AND TERRITORIES

WEST OF THE ROCKY MOUNTAINS,

1871.

FOR THE YEAR 1870.

BY ROSSITER W. RAYMOND,

UNITED STATES COMMISSIONER OF MINING STATISTICS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1872.

c

42D CONGRESS, 1st Session. | HOUSE OF REPRESENTATIVES. | Ex. Doc. No. 10.

MINING STATISTICS WEST OF THE ROCKY MOUNTAINS.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

The report of the special commissioner for the collection of mining statistics in the States and Territories west of the Rocky Mountains.

MARCH 21, 1871.—Referred to the Committee on Mines and Mining and ordered to be printed.

TREASURY DEPARTMENT,
Washington, D. C., March 16, 1871.

SIR: I have the honor to transmit to the House of Representatives the report of Rossiter W. Raymond, special commissioner for the collection of mining statistics in the States and Territories west of the Rocky Mountains.

Very respectfully,

GEO. S. BOUTWELL,
Secretary of the Treasury.

Hon. JAMES G. BLAINE,
Speaker of the House of Representatives.

CONTENTS.

INTRODUCTORY.

WASHINGTON, *March* 16, 1871.

SIR: I have the honor to transmit herewith my report on mines and mining in the States and Territories of California, Nevada, Oregon, Idaho, Montana, Utah, Arizona, New Mexico, Colorado, and Wyoming. The anticipations of an increased prosperity of the mining industry, expressed in my last report, have been realized. Not only the augmented bullion product, a discussion of which will be found in the accompanying report, but an improved tone in the business itself, and the progressive reduction of the burdensome expenses under which it has labored, bear witness of substantial gain.

The year has been marked by comparatively few and feeble mining excitements, such as have in other times caused the depopulation of entire districts, and the emigration of vast throngs *en masse* to the new Eldorados. Something of this kind is the necessary consequence of the enterprise of the free-footed people of the West; it is by "stampedes" that all our new States and Territories have been explored and settled, but the waste and friction of the process are so great that we may be grateful for its gradual subsidence into the forms of slower and more regular progress.

The movements of the year, more detailed accounts of which will be found in the following pages, may be briefly enumerated as follows:

The gold mines of Southern California, near San Diego, discovered in 1869, were the scene of some excitement and activity early in the following season.

The silver discoveries in the Burro Mountains, on the confines of New Mexico, attracted much public attention, but it was speedily shown that these mines require capital for their development, and do not invite the penniless adventurer.

Rumors of rich placers on Peace River, far in the interior of British Columbia, were in circulation early in the season, but the memory of Fraser River, and its disastrous "stampede," seems to have quenched the zeal even of those adventurous souls who generally find the greatest charm of a new discovery in its remoteness and inaccessibility.

Several thousand miners were attracted to the bars of Snake River, mostly from other districts of Idaho; but this region is so near the railroad that the equilibrium of population was soon established, and a manufactured excitement was impossible. Such artificial enthusiasms are usually due to two causes: first, the presence of a crowd of unemployed, adventurous, and sanguine men, who keep up their courage,

moreover, because they cannot get away; and, secondly, to the merchants who have, at great cost, carried stocks of goods to the new districts, and who naturally encourage, by every means, the maintenance of the public interest and the increase of the population. Rapid communications and cheap freight paralyze both these sources of excitement. Both the motive and the means of creating false impressions of the extent and value of the new discoveries are measurably taken away, and the level of truth is reached after comparatively few and feeble oscillations.

The progress of developments upon the Comstock lode gives better promise for the future, and strengthens the opinion I have formerly expressed that this vast fissure will be found metalliferous at greater depths than any yet attained.

Meanwhile other parts of Nevada have sprung into sudden importance. The operations of one or two large companies at Meadow Valley, and the base-metal smelting operations of Eureka, have added heavy sums to the bullion-product of the State. At Austin, Mineral Hill, and elsewhere the Stetefeldt furnace has been steadily in operation, successfully treating, at a great saving in the cost of chloridization, large quantities of refractory silver ores, and establishing itself as the most important of recent improvements in American metallurgy.

The Territory of Utah has witnessed a sudden and rapid development of silver mining, facilitated by the railroad connections, which permit the shipments of ores and low-grade bullion. The comparative cheapness of wages, the comparatively populous settlements of the region, the advanced condition of agriculture, and the now not unfavorable attitude of the Mormon authorities toward mining, combine to relieve this young industry in Utah from many of the disabilities which have attended its introduction elsewhere in the West.

In Colorado the principal novelty of the year was the development of the silver mines in the Caribou or Grand Island district. What will be the future importance and extent of this group of mines is at present uncertain. Two or three undeniably valuable and productive lodes have been opened.

For further particulars as to all these mining fields, together with others of greater age and more familiar fame, I respectfully refer you to the accompanying report.

The labor question, involving rates of wages, length of working shifts, and other issues between laboring miners and employers, has received, in many localities of the Pacific slope, a peaceful though, perhaps, but temporary adjustment. The general result of the disputes and conflicts of 1869 has been the reduction of wages, which the conditions of mining enterprises imperatively demanded, and the cheapness of provisions and clothing rendered reasonable. The miners' leagues, however, still exist in many places, and continue a more or less successful resistance to the inevitable fall in the price of labor. Their most unreasonable demand has been for equal pay to all classes of miners, without regard to

the skill required of them or the danger to which they are exposed. This is a suicidal policy, and I feel sure that it will be everywhere abandoned in the end by the workingmen themselves.

The gradual extension of "single-hand drilling," and the changes in administration which it frequently involves, have suggested in some quarters the employment of Chinese labor underground. It is not my purpose to enter upon the discussion of the so-called "Chinese question." Indeed, I feel that this subject is hardly in a condition to be properly discussed. Before argument can be made conclusive, it is necessary that a basis of ascertained and acknowledged facts shall be obtained; and this vitally essential preliminary has been thus far flagrantly neglected by the disputants upon the question named. Inflamed by political and other jealousies, each party has dealt in wholesale assertion, and each has endeavored to suppress the facts not favorable to its position. So long as there is a dead-lock of contradiction as to the number, character, habits, and capacities of the Chinese in this country, there can be nothing definitely settled as to our duty and policy toward them. I purpose at present merely to contribute some facts with regard to their employment as miners.

Since most of the Chinese in the United States are engaged in placer-mining on their own account, it is evident that they are well adapted for success in that branch. Indeed, it is universally acknowledged that they work with greater economy than the whites. In most cases, they buy up abandoned claims, and reopen them with profit.

But deep mining is quite a different matter, and requires a different kind of skill. A knowledge of the varying hardness, tenacity, and cleavage of rock and vein-stuff, and of the force of explosives and their effects, is required in this work, if the greatest result is to be obtained from a given expenditure of labor and material. Moreover, a considerable amount of muscular strength and endurance is demanded by the incessant and intense labor of wielding the sledge or hammer.

The experience of the Central Pacific Railroad Company, which employed Chinese in the construction of tunnels, first called attention to their qualifications in this direction. A number of attempts have since been made to introduce them into mines, and generally without permanent success. Sometimes the trouble has been the hostility of other miners, sometimes the difficulty of managing the Chinamen themselves.

At Silver Peak, Nevada, the entire force in the Red Mountain mines is said to have been at one time Chinese; but I understand that a change has been made, and white miners are now employed for a part of the work.

The miners in Morey district, Nevada, were last year Chinese, under a white foreman; and the manager declares that they gave him perfect satisfaction, doing as well as an equal number of white men. But the foreman, during the absence of the manager, discharged the whole lot; and no more have been engaged up to this time.

In many quartz-mines and stamp-mills throughout the West, Chinese labor is employed for certain inferior purposes, such as dumping cars, surface excavation, etc. But in most cases there is little gained by it, as these positions could probably be filled as well and as cheaply by boys, old men, etc., from non-celestial climes. The best region for ascertaining the real qualities of this race as miners is, so far as I know, that of the southern mines of California. In Merced, Mariposa, and Tuolumne Counties, for instance, where the decadence of placer-mining has removed a great part of the skilled white labor, many Chinese have been employed for years in quartz-mining. Even before the construction of the Pacific Railroad, there were Chinese miners in the stopes of the Mariposa, Josephine, and Pine-Tree; and in these noted mines they are still employed to a greater or less extent. I have seen in the Mariposa whole shifts of brawny pig-tail wearers, some of whom had followed the business for ten, twelve, or fifteen years.

Putting together the results of experience in all quarters, I arrive at the following conclusions:

1. Neither praise nor condemnation can be sweepingly bestowed upon Chinese miners as a class. They show individual character, just as other people do. Calling them all "John," and treating them all alike, is a measure of ignorance, fatal to successful management. Even the characteristics which they appear to possess in common, whether good or bad, would, I think, disappear if they were less rigorously excluded from the rest of the world.

2. It is troublesome, on some accounts, to run a mine manned entirely by Chinese. They put little faith in the promises of employers, and are pretty certain to stop work if not promptly paid. Even after long experience of fair dealing, they do not seem to acquire confidence in this respect; and they remain to-day, as they always have been, the most reasonable in the matter of wages, and the most unreasonably exact in the matter of payment, of all our laborers. No doubt this distrust is due partly to the difference of race, partly to the injustice and dishonesty with which they have been treated; but, whatever be the cause, the fact is palpable, and not unfrequently seriously injurious to mining enterprises in remote districts, where the money does not always arrive just in time for pay-day, and where the miners, once lost, cannot be immediately replaced.

Another obstacle to the exclusive employment of Chinese is the frequency of their religious festivals and holidays. On these occasions, according to the reports of employers in Mariposa County, they leave the mines *en masse*, and cannot be induced to work, for sometimes a week together.

3. Chinese skilled miners are quite equal to those of any other race. In some instances they surpass white men employed in the same mines. The number of those who have had sufficient experience to give them equal advantages in the comparison is of course small. Apparently,

the natural qualifications of the race for this class of work are very great; but it should be borne in mind that only those Chinese who have a fitness for it are likely to undertake it, while many white men pretend to be miners, though unskillful, on account of the high wages paid to that class. On the other hand, good Chinese miners command increased wages. Already they are paid in many localities nearly as much as whites; and there is no reason to doubt that in the course of time the equilibrium will be established, and the quantity and quality of labor, not the race of the laborer, will become the measure of wages. Chinese miners are now receiving $1 75 and $2 per day, where they formerly worked for $1 and $1 25.

4. In hard rock they do best with "single" drills, of small steel. So do all miners. The use of the small single drill is becoming quite general in our mines, and is found, where circumstances are favorable, to effect a large saving of cost. One objection to it is, that it is likely to involve underhand stoping, since the single-handed drill cannot conveniently be used in upward holes; and underhand stoping is expensive in mines where the "deads" are packed away in the stopes, and where much timbering is required to support the hanging wall. Generally, where small drills are used, the quicker explosives, such as rifle-powder, dynamite, Hercules powder, (a mixture of nitro-glycerine and common powder,) etc., are best.

5. The greatest superiority of good Chinese miners over European miners is their fidelity. Every mining captain knows that the latter, if working by the shift, need watching to prevent them from idling, and, if working by contract, have a hundred ways of getting the better in the bargain. Now, I do not believe this to be a national characteristic. It is simply professional. When Chinamen shall have worked underground for a generation or two, they also may have acquired these peculiarites. For the present, however, it is certainly true that they are far more earnest and faithful than any other miners. In every department they enjoy the universal reputation of conscientious fidelity. Apart from every other advantage or disadvantage attendant upon their employment, apart from the discrepancy in wages, even, this one attribute of fidelity to the interests of the employer will certainly carry the day for the almond-eyed laborers, if our white workmen do not recognize the danger in which they stand, and avert it by far more sensible means than they have hitherto employed. Good workmen, engaged in avocations which require skill or involve peril, must be allowed to receive higher wages than their comrades. Ambitious workmeh must be free to work extra hours, to take odd jobs, to save money for the purposes of study, self-improvement, and advancement, and all workmen must maintain and manifest a desire to earn what they receive. These natural laws being defied, the disastrous result will be inevitable, no matter how long it is postponed; and the punishment will fall heaviest, as it always does, upon the poor. No country, where the common

laborer receives as much as the skilled laborer, can be said to have its industry placed on a secure basis; and no country in which every man cannot freely sell his labor in the market to the employer of his own choice is truly free or likely to be permanently prosperous.

Both political parties on this coast appear to be afraid to speak the truth on the Chinese question. They have settled on a convenient fiction, and they vigorously denounce the importation of "coolies." But the Chinese here are not coolies. They are quite ready to accept the best wages they can get. They even combine, like other folks, in unions, where that is possible. I am told that the Chinese washermen of San Francisco have a union and a fixed rate of prices; and it is even reported that when some traitorous wretch washed shirts below the market rate, they "went for him" and killed him at once.

I repeat, the Chinese will maintain their hold in this country, if they maintain it at all, not by the cheapness, but by the excellence of their labor. Their wages are constantly rising. Before long they will receive everywhere, as they do now in many localities, as much as any man should receive, in view of the cost of provisions and clothing, for the same character of work. The wages question is temporary and will pass away; but the question of character, industry, and skill will remain and constitute the true and dangerous competition of the future.

The sum of the whole matter appears to be, that good Chinese miners are highly desirable; that their number is small; that the employment and training of raw hands is attended with considerable inconvenience; that the best system, where it is practicable, is to include two or more nationalities in one mining force; and, finally, that the question of wages will probably settle itself by a rise in the demands of Chinamen and a fall in the price of Christians. This is the present aspect of the case; and it does not seem likely, under all the circumstances, that the Chinese will either be universally introduced or universally excluded as a race. Individuals will develop, as they should do in a free country, into whatever business suits them best, without reference to their birth or blood. If this seems Utopian, I point to an illustration in the Washington gold mine, near Hornitos, California, where a white superintendent, a black foreman, and a force of yellow miners seem to do very well together. Indeed, one might expect distinctions to disappear underground, since there is no difference of color in the dark.

An event of considerable importance to mining engineers and metallurgists has been the publication of the volume on Mining Industry, of the Report of the United States Geological Exploration of the Fortieth Parallel. The careful and comprehensive review of the mining and metallurgical processes of some of our principal districts, and the sketch of their geological features and vein-phenomena, possess the highest interest and value. Unfortunately the edition of this work authorized by Congress is too small to bring it into general circulation among the communities and classes most directly interested in its contents. I

have, therefore, thought it best to extract from it some of the most practically useful portions, condensing them whenever I could do so without material injury to their sense, and adding foot-notes of my own whenever I desired to add to the text or express an opinion at variance with it.

At the request of General Francis A. Walker, Superintendent of the Census, I examined, with the assistance of Mr. A. Eilers, all the mining returns of the assistant marshals from the States and Territories covered by this report. As might have been expected from the imperfection of the law, which neither authorizes the employment of experts in the collection of the statistics of any manufacture for the census, nor provides blanks suitable for peculiar industries like that of the mining and reduction of ores, these returns were frequently both confused and incomplete. A careful revision and much correspondence with the assistant marshals has doubtless improved them, and it is believed that when published they will contain much information of value. That they do not represent fully the mining industry of the West may be inferred from the discrepancy between the aggregate number of miners accounted for on the "manufacturing" blanks and the number shown by the "occupation" blanks. This subject will be more explicitly discussed by the Superintendent of the Census in the volume devoted to it. Meanwhile I am indebted to the census returns for some items incorporated into the accompanying report, chiefly such as the average wages, product, &c., of certain districts, or rather, of the mines in those districts, which happened to be included in the assistant marshals' returns.

In this, as in every former report, I have occasion to acknowledge with gratitude the assistance which has been generously extended to me in many quarters. The most difficult and dangerous portion of the field-work, namely, a rapid reconnaissance of the mining districts of Arizona, was executed, and the chapter on that Territory was written, by Mr. A. Eilers, my deputy, to whom, likewise, I am indebted for intelligent and zealous coöperation in the arrangement of materials for other chapters of the report. Mr. W. A. Skidmore, of San Francisco, traveled for me as extensively as time and means would permit, among the placer, gravel, and cement mines of California, and assisted me greatly in the conduct of correspondence and other means of acquiring information from localities which it was impossible to visit personally. Messrs. Janin, Hodges, Wheeler, and many others in San Francisco; Messrs. Wolters, Von Schulze, Collier, Reichenecker, and others, of Colorado; Messrs. Alexis Janin, Luckhardt, McMurray, Gray, Boalt, Curtis, Hahn, Van Lennep, and others, of Nevada; Messrs. Atlee, Hurley, and Adams, of Idaho; Messrs. McCormick, Safford, Wasson, and Tyng, of Arizona; Messrs. Reed, Mills, Rinehart, Reynolds, Packwood, and others, of Oregon; Messrs. Roberts, Morrison, and others, of Wyoming—these are but a few names out of many which I do not

enumerate here in full, since I have given credit throughout the report in the appropriate places to all who have contributed to its pages.

Free transportation was furnished to me in my official capacity by the Central Pacific Railroad Company and the Colorado Stage Company; and the powerful assistance of Wells, Fargo & Co.'s vast express system was generously placed at my disposal in the prosecution of many inquiries which would otherwise have been hopeless. During a prolonged experience of travel west of the Missouri River, I have never failed to receive at the hands of the agents of this house a ready personal courtesy and a most intelligent appreciation of my work.

No one can be more sensible of the imperfections of this report than I am. The intense labor of preparing so large a volume in so short a time gives rise by natural reaction to a dissatisfaction in the mind of the author greater than that which the casual reader is likely to experience. Yet I venture to hope that, in spite of many defects, this volume will not fall behind its predecessors in interest and value.

I have the honor to be, yours respectfully,

R. W. RAYMOND,

United States Commissioner of Mining Statistics.

Hon. GEORGE S. BOUTWELL,

Secretary of the Treasury.

PART I.

CONDITION OF MINING INDUSTRY.

CHAPTER I.

CALIFORNIA.

SAN DIEGO COUNTY.

For the first time this county has entered the list of those producing bullion, and though the shipments are as yet small, they bid fair to improve rapidly.

The mines are situated forty-two miles northeast of the town of San Diego, in a range of mountains known as the Isabella Mountains. They were discovered late in the fall of 1869—it is said by a party of prospectors returning from Arizona—and the extraordinarily rich ore from the ledges first located, among which the Washington seems to be the most prominent, caused considerable excitement on the Pacific coast in the spring and early summer. This threatened to grow into a regular stampede at one time, but subsided soon when it was found that the riches were not available without the aid of considerable capital. Several districts were, however, organized, and a town, Julian City, sprang up at once in the heart of the region.

C. A. Luckhardt, M. E., who visited the locality early in 1870, reports to me the following:

Cuyamac or Julian mining district is situated in San Diego County, California, a distance of forty-two miles by stage-road, in a northeasterly direction from San Diego City, in a range of mountains called the Santa Isabella Mountains, which course north and south, lying between the Pacific Coast range and the San Bernardino range of mountains, and have an elevation of 3,000 feet above sea-level. It was located in the early part of 1870, and created much excitement, caused by exaggerations of the richness of the gold veins discovered. The Cuyamac Mountain, part of the Santa Isabella Mountain, is thickly covered with nut-pine timber, abounds in sweet-water springs, and has many very fertile plateaux covered with verdure. Julian City, the center of the district, contains about two hundred houses and tents, with a population of four hundred, which, however, is very varying. The main mass of the Cuyamac Mountain consists of mica slate and hornblendic porphyry, coursing northeast and southwest, standing almost vertical, and bounded westward by basaltic rocks, which have overflowed its western boundary of garnet porphyry. The veins are very numerous, lie on the western and southwestern slopes of the mountain, and run in almost every conceivable direction, subject to the irregularities of the hornblendic porphyry. The larger veins run northeast and southwest and are imbedded in the slate. Their dip is from 70° east to almost vertical. They are narrow and have no bold outcrop, and only in places have clearly defined walls been laid open. They have quartz as gangue, and vary from ½ to 3 feet in width.

Although many locations have been made, it must not be supposed that each represents a vein. Many claims are often on the same vein, and many have nothing more than a few detached boulders, embedded in alluvium and debris, for a foundation. Gold is the only precious metal which the veins carry; accompanying it are traces of antimonblende,

which has been erroneously mistaken for silver ore. The gold occurs in grains and also in thin flakes, and is about 790 fine. It is disseminated very sparingly in the gangue, but occurs in rich pockets at intervals. No base metal accompanies the gold; the quartz is in most instances perfectly white and dense, not even stained by iron, although pyrites occur in traces in some veins. Besides many others, the Washington, Hidden Treasure, Headen, Helvetia, are the most noteworthy. They vary from 18 inches to 2½ feet in width, and have yielded rich pockets containing from ½ to 1½ tons of ore, but their average ore will not exceed $25 per ton.

Two stamp-mills, after the Washoe pattern, comprising fifteen stamps, have been erected in this district, and are doing well at present. The district is new, and explorations in depth are very limited, not exceeding 80 feet in any mine, and as far as work has progressed the veins show less gold in depth than at the surface, and pockets occur less frequently. In this respect Cuymac district is similar to the Aurora mining district of Esmeralda, Nevada, which also yielded in its infancy considerable gold near the surface, but not one mine has ever been profitably worked.

The geological features of the country lead to expect substantial veins which will last in depth, but they are narrow, and it can only be hoped that through economical management their owners may meet with success and be enabled to explore them sufficiently to prove their actual merit.

Leaving Cuyamac district and descending the southwestern slope of the mountain for four miles, the low hills binding the Santa Isabella Valley are encountered; here placer-mining has been carried on, but abandoned, the gold being very thin and flaky, and too sparingly deposited to pay.

Since Mr. Luckhardt's visit more mills have been erected in this region, among which is a Wilson steam stamp-mill. It commenced to run in the middle of June, and ran most of the time until November, though it had to lie idle often, in common with all the mills, because there was no ore to crush. In this respect the San Diego gold region has undergone the same experience that hundreds have gone through before, and it is surprising that after all the experience gathered elsewhere these blunders should be repeated to-day. I mean the erection of mills far ahead of the capacity of the mines before the latter are opened.

Mr. Dougine, the manager of the Wilson steam stamp-mill, has made a number of experiments with from 60 to 90 pounds of steam and a varying number of drops, &c., but obtained the best results with 70 pounds of steam and 206 drops per minute. On August 10 he crushed 10 tons 800 pounds of Hayden rock in eight hours forty-five minutes, using *one cord* of wood, (oak.) On August 11, 8,590 pounds of the hardest rock obtainable were crushed in five hours, with 65 pounds of steam. On August 12, with 68 pounds of steam, to crush 10,800 pounds of ordinary rock, required four hours fifty minutes. In July, 51 tons were crushed in forty-seven hours. The average amount of ore which can easily be crushed in a day (of twenty-four hours) is 28 tons, with a No. 6 slot-screen, and using not over three cords of 4-foot wood; the average consumption of fuel is one cord to 10 tons of ore. The durability of the mill is very great, no breakage having occurred, and there being no signs of any probability of a breakage. In every part the mill has worked wonderfully well. It took just six days to set up the machine ready for work. It is simple, durable, economical, and efficient. Taking these points into consideration, and not forgetting its comparatively

very low cost, it would seem that the mill must be pronounced a great success. It is thought that, at San Diego, $6-ore can be mined and milled at a profit where this mill is used and the same party owns both mine and mill. Four-foot oak costs in the district $3 per cord, and for custom work the mill rates are: For sample lots, $10 per ton; for 50-ton lots, $7; for 100 tons and upward, $6 per ton. It should also be stated, in connection with the above figures, that the same boiler which supplies the steam for the Wilson stamps runs two steam-pumps, one for feeding the boiler, and one for pumping back the water from the settling-tank, this last being necessary on account of the rather scanty supply of that article.

I insert the following milling results of lots of ore from different ledges in the district. They are instructive and give a very fair idea of the richness of the surface ores from various points:

Mine.	Amount treated. Tons.	Yield per ton.
Lone Star	7	$7 00
Do	5	70 00
Shamrock	7	3 50
Eagle	10	2 90
Do	5	2 75
San Diego	19	15 00
Do	51	6 00
Owen's	16	51 00
Keystone	4	7 00
High Peak	10	42 00
Sherman	4	4 82
Hannon	3	3 50
Pride of the West	1½	31 00
White Fawn	3	0 37
North Star	6	4 50
North America	6	4 00
Monitor	6	4 00
Ella	3	1 25
Forty-Nine	12	12 50
Hayden	19	40 00

Shipments of bullion from the Julian district commenced in April, and up to the middle of September $10,341 had been shipped by Wells, Fargo & Co., and 310 ounces, worth about $18 per ounce, or $5,580, by Panly & Son, making in all about $16,000. I am not informed as to the shipments made after the time indicated, but in December it was reported that little or no rock was being taken out, the miners lacking the means and energy to develop their claims. The mills were making hardly half-time, and it was feared that the law-suit, in regard to the Cuyamac grant, which threatened to deprive the miners of their claims, would be decided against them. I have not learned the final result of the suit, but am informed that it has reached its termination late in December.

SAN BERNARDINO COUNTY.

As far as actual production is concerned, this county has little to boast, the only quartz-mining enterprise reported being that of G. E. Moore, at Belleville, who took out, with six men, in three months, 120 ounces of gold, worth $1,700.

Of higher importance are the late discoveries in the Clark district, which, together with the mines again taken up in the Yellow Pine district, just across the line, in Nevada, have caused quite a stir in the Pacific States.

The following report on this district as well as that on the Amargoza district is from the pen of Mr. C. A. Luckhardt, M. E.:

The Clark district is situated thirty-three miles southerly from Yellow Pine, in San Bernardino County, California, on the eastern slope of Clark Mountain, which is a portion of the Opal Mountains. It was discovered and located in the latter part of 1869, and contains now probably forty settlers, all miners. There are no agricultural lands, but water and fuel in abundance. It is worthy of record on account of the principal lode of the district, the 'Copperworld.'

The Clark Mountain is composed principally of porphyries broken through by belts of gabbro, in which the metalliferous veins of the district occur. The porphyry belt on the west bounds on mica, slate, and syenite, which reach to the lower hills of the western boundaries of the Colorado River Valley, formed of sandstones and slates.

There has been but little work done in the district as yet. Several veins have been located, carrying principally copper ores, accompanied by galena, and bearing a variable percentage of silver. As gangue matter, quartz occurs principally; calcspar is subordinate. The Copperworld is a stupendous lode, to all appearances a contact-vein. having gabbro above and porphyry as footwall. It crops out from 30 to 45 feet in width, for 500 feet in length, carries quartz and calcspar as vein matter, and copper ore, with a percentage in silver varying from $30 to $100 per ton, with some galena and blende.

As yet only a few tons of ore have been extracted in order to ship them to San Francisco for experiment. No further explorations have been made, which prevented me from investigating the character of the vein in detail. A vast amount of ore stands in view, averaging 38 per cent. of copper and $50 in silver per ton, and the intentions of the company are, on receipt of the result of the shipment sent to San Francisco, to commence operations on a large scale.

The Amargoza district lies in San Bernardino County, State of California, sixty-five to seventy miles in a westerly direction from Yellow Pine, in an isolated mountain called Amargoza Mountain. Amargoza Mountain is composed of porphyry and granite, void of all vegetation. The nearest fertile soil is in Amargoza Valley, fifteen miles north from the district; here there is also sweet water.

The district was located in 1856 for the purpose of gold quartz and placer mining, but the owners had to abandon the territory to the Indians. Since then it has been relocated in 1863, when I visited it for the first time, and a company established a quartz-mill and met with good success for over a year; afterward work was discontinued for reasons not known to me, and in 1870, on my last visit, I found the district deserted.

The veins of the district are narrow, and are embedded in porphyry, have quartz as vein matter, and carry gold free; the only accompanying metal is iron, as a sulphuret, and in small quantity; the extreme dryness of the atmosphere preventing speedy decomposition.

The district is remarkable for the Amargoza vein, the principal one. It varies from 6 to 10 feet in width, has granite above and porphyry below, and a general north and south course, dipping 78° west.

The prominent vein-matter is a compact quartzite, carrying free gold, which is universally distributed throughout the vein, both as coarse and fine gold, in grains of a rough surface, not in leaves. Amargoza Mountain has suffered from volcanic eruptions similar to the Potosi Mountains at Yellow Pine, but the metamorphism is wanting. A curious phenomenon is observable in the Amargoza vein, namely: Near the

surface it is in places 15 feet wide, contains masses of black hornblendic syenite, not resembling the granite of its overlay, mixed with and enriched by the quartzite of the vein, and this granite bears coarse gold, often in nests. The vein has been attacked by various tunnels and shafts, and worked to a depth of 120 feet in places, where this granite still occurs, but not in such large masses, carrying gold; but there is here a difference in the quality and shape of the gold from that which the vein proper carries. No iron is visible in the granite. Near the surface gold was found in pockets, one of which yielded $11,000, but the average of the ore was about $60 per ton. In depth the gold became finer, more universally distributed through the vein, and the average may be called $18 to $20 per ton, of which quality thousands of tons exist now, which only await the time when the surrounding country will be more settled to be beneficiated profitably.

The total population of this county, according to the census, is 3,988; Chinese, 16.

LAKE, SANTA CLARA, AND FRESNO COUNTIES.

These three counties contain only quicksilver mines and are the only ones in which this metal is produced. The product of quicksilver was not large, and advanced steadily during the latter part of 1870. The following was the product of the different mines during the year from June 1, 1869, to June 1, 1870, as given by the census returns:

In Lake County the Redington Company employed 150 hands and produced 5,541 flasks, worth	$166,230
In Santa Clara County the Quicksilver Mining Company employed 500 men and produced 17,000 flasks, worth	422,450
In the same county the Santa Clara Guadalupe Company employed 40 men and produced 524 flasks, worth	19,000
The New Idria Mining Company, in Fresno County, employed 350 men through the year and produced 10,500 flasks from 8,000 tons of cinnabar, worth	420,000
Total, 33,565 flasks, worth	1,027,680

In Lake County, Knox & Asborne have started a mine, employing 35 men for some time, but no results are as yet known to me.

In regard to the causes of the great rise in quicksilver, the San Francisco Bulletin contained an article in December, 1870, which, on account of the clearness with which it treats the whole subject, is worth reproduction in this report:

The price of quicksilver has been again advanced 10 cents per pound, making the present price 90 cents, a higher figure than has been reached for many years. As much has been said and written concerning the recent advances, the monopoly of the article, both here and in Europe, and the present status of the several California mines, it will be worth while to give a little history of the speculations and combinations in quicksilver for some years past, which will afford some insight as to the manner in which "big things" are put up for the benefit of a few speculators at the expense of the great industries of the country.

For some years prior to 1868, the supply of quicksilver had been largely in excess of the demand, and the price here had been kept up only by the leading speculators—Messrs. Barron & Mills—having contracted for the entire product of the new Almaden mine for two years, with a limit of 50,000 flasks, at $30 per flask, and also by purchasing the entire product of the Redington and New Idria mines, the yield of these two being at that time but about 4,000 flasks per annum each. In April, 1868, the contracting parties, finding that the production was largely increasing while the demand remained about the same, declined making any further contract for purchasing, and after considerable negotiation a combination was finally arranged between the new Almaden, represented by S. F. Butterworth, the New Idria, controlled by Barron & Mills, and the Redington mine, owned by Redington & Livermore, for two years. The

New Almaden, which claimed to have a capacity for delivering 4,000 flasks per month, agreed to limit their production to 24,000 per annum, and the Redington and New Idria, each of which claimed a capacity of 1,500 flasks per month, agreed to limit their product to 10,000 flasks per annum each. Barron & Co., under the contract, were to be the shipping and foreign agents, and Redington & Co. were to have the exclusive local sale. The price to consumers in the Pacific States was fixed at 60 cents per pound, or $45 90 per flask; while the product sent abroad, being the much larger portion, sold for from $20 to $40 per flask; the average of home and foreign sales netting to the combination about $35 per flask. The product of all the mines fell considerably short of anticipation, the New Almaden delivering but about 18,000 per annum, the New Idria about 8,000, and the Redington 7,000.

In the early part of 1870, we find by the annual report of the New Almaden Company, published in New York, that they were in a very bad financial position, a judgment of $55,000 in gold having to be immediately paid; and, in addition, there was a large amount due the Bank of California, payment of which was imperatively demanded. In this emergency, their managing agent in San Francisco, S. F. Butterworth, was authorized to make some financial arrangement to relieve their pressing need, and that gentleman, in pursuance of the object, entered into a contract with D. O. Mills, by which all quicksilver belonging to the New Almaden in foreign markets (about 20,000 flasks) was sold for $32 per flask, and the entire product of the mine for two years up to April 1, 1870, (with a limit of 2,000 flasks per month,) sold for $31 per flask.

Upon the expiration of the combination between the New Almaden, the New Idria, and the Redington mines, the owners of the last-named company, knowing that the New Almaden and New Idria were controlled by the same parties, declined either to enter into a new combination or to contract to sell their product at anything like the price paid for the New Almaden; but, after considerable negotiation, finally entered into a contract with Barron & Mills to sell their entire product for ten years. The price was not made public, but it was generally understood that they received $40 per flask, and agreed to limit their product to the same amount as in the previous combination, 10,000 flasks per annum. The great falling off in the product of the New Almaden, which almost immediately declined to less than 1,000 flasks per month, and the subsequent lease of the Spanish mine to the Rothschilds, who advanced the price in London £2 per flask, has enabled the holders here to advance the price until it has now reached 90 cents per pound, or $68 85 per flask, and the owners of the Redington mine, who, under their contract, still hold exclusive control of the local sale, now have the satisfaction of delivering the quicksilver to Barron & Mills at $40 per flask, and reselling it under their orders for $68 86. Strangely enough, the product of their mine, which started off at the full limit, has, as the price increased, gradually dwindled down to about 300 flasks per month, and, although it is well known that they have recently opened new and large veins of rich ore in their mine, they are now, it is said, running but one furnace, and, it is intimated, may even be obliged by "circumstances over which they have no control" to suspend operations entirely.

There are several other mines of small capacity now being worked—the Pope Valley mine, near Napa, and one or two in Lake County, near the Redington mine—all of which may be made to pay at the present high price of quicksilver, and it is to be hoped that they will yet be worked up to a product which will end the monopoly that is now damaging the interests of the coast to an extent only realized by those who are concerned in mining operations. The future outlook, which is not a flattering one for consumers, may be summed up about as follows: The Spanish mines are under lease to the Rothschilds, who will control the foreign market; the New Almaden, which formerly produced as high as 4,000 flasks per month, has fallen to less than 1,000, and, it is said by those best informed, will be likely to decline considerably from that figure.

The New Idria, besides being involved in litigation which may compel its stopping, has also fallen off greatly in its yield, and the product of the Redington mine is purposely kept at a low figure, because its owners prefer to keep their ore in the mine rather than deliver it at the price agreed upon under a contract which only compels them to deliver what they manufacture. The only chance for a reduction in the price is in the increase of product from new mines, or from the smaller mines now being worked, and it is to be hoped that the attention of capitalists may be turned to this subject. It is lamentable that an article so indispensable in lode-mining, and even in a great part of our deep gravel operations, should be pushed to an extreme price by speculative combinations, which necessarily depress, to some extent, a leading industry of the State, and greatly diminish the profits of those who continue to prosecute it.

The population of these counties is given by the census as follows:

	Total.	Chinese.
Lake	2,969	119
Santa Clara	26,246	1,520
Fresno	6,336	427

INYO COUNTY.

This county, mentioned favorably in last year's report, has steadily advanced in mineral productiveness. Some gold quartz-mining enterprises have been in operation, but the product from these is much smaller than that from the argentiferous galena lodes, which so soon after their discovery commenced producing regularly, and consequently came into favorable notice.

Nine gold quartz-mining enterprises are reported to me. They employed together thirteen men an average of 8.6 months, and the wages paid were from $50 to $75 per month, according to the work to be performed. The total product was $67,000, showing that the mines are worked in a very small way. The most prominent claims are the following:

	Product.	
	Amalg., oz.	Value.
McMurray and Main	1,044	$14,625
Pedrick & Co	630	10,080
Mendeville & Co	620	10,000
Larger, John	730	10,720

Only seven men were employed on these claims; four on the two first mentioned during the entire year, one during six months by Mendeville & Co., and two during eight months by John Larger.

The discoveries of argentiferous galena in the vicinity of Owen's River at Cerro Gordo are important, and I therefore give it, in addition to the information furnished in my former report, a more extended notice this year.

The observations here recorded were mostly made on the spot by Mr. C. A. Luckhardt, an engineer well known on the Pacific coast. His report to me is given with such additions as I am enabled to make from information received at a later date.

Cerro Gordo or Lone Pine mining district and vicinity.—Cerro Gordo mining district is situated in the southwestern portion of Inyo County, in a range of mountains called Inyo Mountains, the southern extension of the White Mountains. They are bounded by Owen's Valley and Owen's Lake, and Lone Pine Valley, formed by the Palisade and Inyo Mountains, on the west; by Saline's Valley, formed by the Pahnamint and Inyo Mountains, on the east; and by the Coso Mountains, which are the southern extension of the Inyo Mountains, on the south. The Inyo Mountains have a general north and south course, and are elevated from 7,000 to 8,000 feet above the level of the sea. They are a rugged chain of mountains, slope more to the westward (about 2,500 feet into Owen's Valley) than they do to the eastward, where high plateaus gradually connect them with the Pahnamint Mountains.

The general topography of Owen's Valley is too well known to require extended notice here. Suffice it to say, that its soil for over thirty miles in length, varying in width from four to six miles, is excellently watered and offers rare inducements for agriculture. That portion of the valley where Owen's River empties into Owen's Lake is termed Lone Pine Valley. Here Lone Pine City is situated. It is two hundred and sixty miles from Los Angeles by wagon-road, and connected with Visalia, ninety miles distant, by stage-road. The nearest town to Lone Pine is Fort Independence, (a Government post,) which lies eighteen miles to the northward, and to which leads a stage-road.

Lone Pine City is but a late settlement, comprising about two hundred houses and a population not exceeding seven hundred. In its immediate vicinity are fields where agriculture is carried on with good

results. Near to the city are two mill-sites, with reduction works—the larger one belonging to the Cervantes Mining Company—about three-fourths of a mile from town, comprising three furnaces, crushers, &c., of thirty tons beneficiating capacity, the whole driven by water-power. Within one-fourth to one-half mile from Lone Pine runs Owen's River, which is navigable for flat-boats at all seasons of the year from Owen's Lake up to Owensville, a distance of sixty-five miles.

The mountains which bound Lone Pine Valley on the west, and which slope very abruptly eastward into Lone Pine and Owen's Valley, are worthy of mention. The most prominent peaks are Mount Whitney, 15,000 feet; Mount Williamson, 14,300 feet, and Mount Tyndall, 14,000 feet high. These mountains abound in timber lands, and furnish water in sufficient quantities for excellent mill-sites. Although timber is abundant, all lumber for building purposes comes, as yet, from a point fifty miles to the northeast of Lone Pine, and is, consequently, still high in price.

Cerro Gordo City, the center of the mining district, is situated about 7,200 feet above the ocean level, and nineteen miles by wagon-road in a southeastern direction from Lone Pine City. Its elevation above Lone Pine is about 2,000 feet. It lies in a deep ravine on the western slope of Inyo Mountain, and has at present about five hundred and fifty inhabitants. The mountains here are almost barren of vegetation, and there is but a limited amount of fuel. Water is very scarce. At present there are but three wells of from 20 to 60 feet in depth, and some water (3 to 4 inches) has been brought in pipes a distance of four and a half miles, which, however, is barely sufficient for home consumption. This fact has been a great detriment to operations at Cerro Gordo thus far, but in time it can be remedied by sinking more wells, and bringing water from a point nine miles north of the city in pipes or ditches and flumes. There is quite a supply at the locality spoken of, and the enterprise will involve a cost of not more than $80,000.

That portion of the Inyo Mountains in which Cerro Gordo mining district is situated consists of a single chain, having a general northwestern and southeastern course. It is not exactly detached from the Inyo range, but a depression of about 600 feet to the northward separates it apparently, while southward it falls gradually toward Owen's Lake. Its cañons and ravines have a general southwest direction, descending toward Owen's Valley; they are abrupt for about two miles from the mountain summit, but farther south the slope is more gradual, and low hills, for a distance of about two miles, intervene between the steeper parts and the valley. The main bulk of this range, which is called Cerro Gordo, is composed of metamorphic rocks, which contain heavy belts of crystalline and compact limestone, and are intersected by porphyries of various character. The lines of contact are promptly discernible, even where the slates are partly covered over by soil, the latter being mostly ferruginous clay-slates, but sometimes they are calcareous. The lower portion of the southwestern slope, about one and a half miles from Owen's Valley, shows a massive belt of siliceous slates. They run parallel with the main mountain-chain, dip southwest, and seem to be the division line between the sandstone formation of the lowest hills and the metalliferous belt of the mountain above. In this metalliferous belt, limestone is predominant. The veins occur either altogether in it, or as contact-veins. In the former case, the foot-wall of a vein is generally discernible by a clay-seam, forming the division line. The hanging and foot-wall of a vein are in many instances distinguished from one another by the different crystalline structure of the limestone, but

in most cases the walls are compact limestone, showing only here and there signs of a crystalline structure, while the vein-matter is a crystalline limestone. In the second case, that of contact-veins, we have generally slate overlying, quartz or quartzite predominating as vein-matrix, and compact limestone as foot-wall. The outcrops of these veins are often very bold and massive, but in many instances they have suffered a dislocation sideways, the cause of which is fully explained by the abruptness of the cañons. This is very apt to mislead as to the actual width or dip of a vein, and even as to its location.

The course of the veins is northwest and southeast, with a changeable southwesterly dip, except in the extreme northern portion of the district, where the veins turn more and more to an east and west course, and dip north. The northwest and southeast course is a general rule, but is not exempt from exceptions, as metalliferous cross-courses exist in the district: for instance, the Soledad vein, which strikes the St. Lucas and Abundancia at an angle of 65°, and has an almost north and south course, and dips west. Most of the veins dip from 70° to 60° except near the surface, where irregularities are naturally to be expected and are frequently met with. The veins of the district may be divided into two distinct classes, according to their contents, namely: 1. Those which carry mainly argentiferous galena ores; and 2. Those which carry principally copper ores.

The first class have invariably limestone, the second class predominantly quartz and quartzite, as vein-matter. The second class are best defined and the more massive of the two, and are also less subject to irregularities near the surface than the first class. They carry the larger amount of precious metal, and are in consequence termed 'silver leads' throughout the district, while the first class are known as 'lead leads.'

Local circumstances have been the cause, that up to the present time but a limited amount of work has been done on the veins, hardly sufficient to realize the actual merits of many of them. The aim of all work done so far has been always to produce in the shortest possible time the largest amount of ore in order to *realize*, and judicious work, namely, *producing and developing at the same time*, has been neglected. Every mining district in its infancy is, of course, subject to this, especially if its yield can be made available forthwith, as is and has been the case in Cerro Gordo ever since its discovery.

To facilitate a description of the ores I shall retain the terms in vogue in the district, calling the above first class "galena ores" and the second class "silver ores."

The ores of the district are of various nature and character, the latter undoubtedly attributable to the character of the rock, which forms the main bulk of the vein-matrix, and also to the nature of the rock which occurs in the immediate vicinity of the veins. They are argentiferous galena, (coarse and fine crystallized,) carbonate of lead, argentiferous copper ore, principally as gray copper ore, and iron pyrites in various stages of decomposition.

Subordinately occur antimonial silver ore with traces of speiss-cobalt, silver-copper glance, silver-bearing malachite, azurite, sulphuret of silver, sometimes partly decomposed and mostly free from refractory metals, and native silver, which occurs often in the malachite and azurite.

Gold is found in traces only, and occurs mostly in the northern portion of the district, although some of the veins situated in the extreme southwesterly part of the district show it sometimes. Nearly all the veins carry more or less of all the above-named ores, but, as stated

above, the veins bearing limestone as gangue matter have galena predominant, accompanied by iron pyrites, which, near the surface, are decomposed to oxides, coloring the entire vein-matter yellowish and red, and entirely veiling its texture. The ore in these veins, as far as can be observed by actual explorations made up to the present time, occurs in nests, pockets, and irregularly shaped deposits, which run generally parallel with and lie very close to the foot-wall of the vein. These vary in width from 1 to 15 feet, and have in several instances been worked to a vertical depth of 40 feet and over 120 feet in length on the strike of the vein, showing no signs of pinching; on the contrary, in two instances, a depth of 150 and 170 feet has been attained, where the iron pyrites are only partially decomposed, and here the silver value has been found unchanged in the ores. The lowest workings of the district have in no instance reached the water-level, and it is impossible to say how the silver value of the ores will hold out where they will be found entirely undecomposed. So far this has not changed at a depth where the accompanying iron ore changed its entire character, and this must lead us to expect a continuation of the silver value of the ores in depth. The galena occurs in various forms, from the coarsely crystallized to the granular and almost solid texture; and although the former theory of the German miners, that the finer and closer the crystals the richer is the ore in silver, is now considered wrong, this has nevertheless been found to be the case in Cerro Gordo. A sample of coarse crystals of galena, from the Union mine, 25 feet below the surface, yielded $84 32 in silver and 67 per cent. of lead, while a similar sample, from the same vein, taken from 60 feet below the surface out of the Santa Maria tunnel, where the accompanying iron pyrites were little, if any, decomposed, gave $91 13 in silver and 58 per cent. of lead. The finely crystallized galena from the Union mine, from about 40 feet below the surface, was found to contain 61 per cent. of lead and $117 53 in silver per ton of ore.

The class of veins bearing quartz as vein-matter and cupriferous silver ores carries galena only subordinately. The ores occur generally in seams from 2 inches to 5 feet wide, and can be followed with some degree of certainty as to duration in depth. They lie generally in or near the center of the vein, wide and narrow at intervals, and when, as is sometimes the case, they hug the hanging wall for some distance, they contain rich ores. But when the entire fissure from wall to wall is filled with ore, it is generally poor in silver and much mixed with vein-matter. In some instances the work done in depth on these veins has proven that the ore improves in quality and quantity as depth on the vein is attained, as, for instance, in the St. Lucas mine. The outcrop of this vein shows malachite stains profusely in many places, bearing $7 to $12 per ton in silver; 45 feet below the surface no highly oxidized copper ores are found, and 4 feet of the vein-matter bear $91 19 silver per ton.

Sampled cupriferous ores yielded in silver as follows:

A. A gray copper ore, containing antimonial ores, a refractory ore for smelting, which forms the greater portion of the ore of the St. Lucas mine, contained per ton $93 60 in silver.

B. A highly oxidized ore, containing silver-copper glance, forming an average of 1 foot in width of ore, 30 feet below the surface, in the San Ignacio mine, contained per ton $161 78 in silver.

C. A still higher oxidized ore, mostly antimonial, with stains of lead-ochre, some malachite, and azurite, forming a seam 6 inches wide in the San Ignacio mine, close to the surface, yielded $289 05 in silver and $40 51

in gold; total, \$329 56 per ton. This is the only sample from the entire district which has come under my notice showing an available quantity of gold.

D. A sample of azurite, apparently not carrying silver, from the outcrop of the St. Louis mine, yielded \$106 81 in silver.

In order to acquire a good insight into the value of the ores of the district as a whole, from twenty-seven to thirty mines were visited, and the ores sampled as they occur, regardless of assorting. An average sample taken from all the samples thus obtained assayed \$68 52 per ton silver as an average for the entire district. By proper assorting this yield can be raised to \$143 91 per ton, as will appear below.

The following is a list of the assays made, giving notes on the veins from which the samples were taken.

I. Galena ores of Cerro Gordo:

1. Sampled 8 feet ore-width; much vein-matter; about $\frac{1}{5}$ ore to $\frac{4}{5}$ waste; from Freiburgh No. 1 mine; assay, \$25 12.

2. Sampled 3 feet ore-width; about $\frac{1}{7}$ waste; easily assorted; some copper; from San Felipe mine; assay, \$12 56.

3. Sampled 2 feet ore-width; about $\frac{1}{4}$ ore, $\frac{3}{4}$ waste; containing no copper or antimony; from Union mine; assay, \$25 62.

4. 6 feet ore-width; about $\frac{1}{2}$ ore, $\frac{1}{2}$ waste; some copper; no antimony; from San Aberlino mine; assay, \$54 97.

5. 2 feet ore-width, in a vein 15 feet wide; about $\frac{2}{3}$ ore to $\frac{1}{3}$ waste; contains some antimony and very little copper; from Union mine; assay, \$91 10.

6. 4 feet ore-width; very ferruginous; hard to assort; traces of copper; from Front mine; assay, \$58 11.

7. $1\frac{1}{2}$ feet ore-width; $\frac{2}{3}$ ore to $\frac{1}{3}$ waste; galena in spots; no copper; hard to assort; Guaymas mine; assay, \$36 23.

8. 16 feet ore-width; very ferruginous; can be easily assorted; $\frac{1}{3}$ ore, $\frac{2}{3}$ waste; from Union mine; assay, \$45 55.

9. 17 feet ore-width; ore in seams; $\frac{1}{5}$ ore, $\frac{4}{5}$ waste; can be easily assorted; the only thing accompanying the galena are very soft oxides of iron, cemented together by an argillaceous mass; from San Felipe mine; assay, \$12 56.

10. 6 feet ore-width; no antimony or copper; about $\frac{1}{4}$ ore, $\frac{3}{4}$ waste; the ore occurring in pockets; from Freiburgh mine; assay, \$43 98.

11. 4 feet ore-width, in a vein 12 feet wide; $\frac{1}{3}$ ore, $\frac{2}{3}$ waste; not so easily assorted; from Asteroid mine; assay, \$42 46.

12. 14 feet ore-width; an average throughout all the stopes of the Union, Front, and Freiburgh mines; $\frac{1}{2}$ waste, $\frac{1}{2}$ ore; assorted by hand, but not very carefully; assay, \$100 53.

13. $1\frac{3}{4}$ foot ore-width; Queen City mine; the vein is throughout 7 feet wide; can be assorted in extracting the ores from the mine easily to $\frac{1}{3}$ ore to $\frac{2}{3}$ waste; assay, \$84 82.

II. Copper ores of Cerro Gordo:

1. 8 feet ore-width, on outcrop; only stains of malachite visible; mine not developed; cannot be called ore; sampled as a prospect; from Abundancia; assay, \$6 28.

2. 2 feet ore-width in vein 24 feet wide; mostly malachite and antimonial ores; easily assorted to $\frac{3}{4}$ ore, $\frac{1}{4}$ waste; from Abundancia mine; assay, \$80 10.

3. $2\frac{1}{2}$ feet ore-width; highly oxidized ore; mostly copper and antimonial ores; $\frac{1}{4}$ waste, $\frac{3}{4}$ ore; vein 10 feet wide; San Ignacio mine; assay, \$316 14.

4. 7 feet ore-width; some galena; not refractory ore; ½ ore, ½ waste; from San Ignacio mine; assay, $161 78.

5. 8 feet width of the entire vein of No. 4; San Ignacio; can easily be assorted to ⅛ ore ⅝ waste; from poor portion of the mine; assay, $31 42.

6. 5½ feet width of vein; sampled as it would be taken out before any assorting could be done; ore in spots; no galena; can be assorted easily by hand, say $\frac{1}{16}$ ore, $\frac{15}{16}$ waste; from Grand Poder mine; assay, $10 98.

7. 4 feet vein-width; docile ore; little lead, say ⅓ ore ⅔ waste; from the Guaymas mine; assay, $47 13.

8. 2½ feet ore-width, being two separate pay streaks in a vein 6 feet wide; does not require much assorting; contains some antimonial ores; from Candelaria mine; assay, $105 39.

9. 3 feet ore-width, vein 4 feet wide; contains considerable galena, is assorted to about ¼ ore ¾ waste; contains antimonial ores; from San Lucas mine; assay, $108 06.

10. A vein 3 feet wide; San Benito mine; about ½ ore ½ waste; no galena. This is a sample from the mine and from the dump which was assorted ½ ore ½ waste; ore can be amalgamated, and may be called an average; assay, $106 83.

11. A vein which is 27 feet wide at the outcrop, showing about 10 per cent. of galena and silver copper-glance, very sparingly distributed throughout the vein. One ore-seam is 18 inches, widening and narrowing along the outcrop; from Abundancia; not developed much; assay, $7 85.

12. 3½ feet ore-width; mostly oxidized ores; vein is 5 feet wide; easily assorted, to about ⅘ ore, ⅕ waste; from Asteroid mine; assay, $105 75.

13. Several ore-seams, from 2 inches to 1 foot in width, on a vein 6 feet wide, making in all probably about 26 inches of ore width; from Fermin mine; ore fit for wet process of beneficiation; assay, $115 15.

14. The ores from the Robinson, Chevall, Sacramento, Reindeer, Omega, San Benito, Tresilos, Alpha, San Louis, and Queen of the West, were also sampled. But little work has been done on these mines. They are situated in the southern portion of the district. An average assay of $42 11 per ton was obtained. The ores of all these resemble one another very much, and none of the veins exceed 6½ feet in width. All the foregoing samples, taken together, give an average of $68 52 silver per ton. They were taken with the object to get at the real merits of the mines as a body, with little assorting. They can certainly all be assorted to ⅓ ore to ⅔ waste, with a loss of 25 per cent. of their actual assay value. This would bring the average to $154 17 per ton; and even if we admit a loss of 30 per cent., the silver value would still be $143 91. Much of the success of the district depends upon the careful classification and assorting of the ores. Those ores bearing much gangue matter, and at the same time docile, (highly oxidized,) can easily be assorted from the others, and reserved for wet amalgamation, as, for instance, the ores from the Grand Poder, Candelaria, Valenciana, Tresilos, Mejicana, Portuguese, and San Benito mines. Those veins carrying refractory ores, by far the majority, must be freed from the accompanying gangue matter as closely as possible and beneficiated by smelting. This dressing is rendered easy by the great difference in the specific gravity of the ore and the barren rock.

The most prominent mines are, the Union, San Ignacio, Freiburgh, San Felipe, St. Lucas, and Belmont; about sixty mines are located and prospected. I have pointed out already that the mines can be divided

into two classes, and I shall therefore describe one belonging to the so-called "lead mines," and two belonging to the "copper or silver mines," which will suffice to impart an intelligent idea of all the mines of the district.

San Ignacio, (Copper and silver mine.)—The vein has a general direction of east 10° south, dipping southwest. It is embedded in compact limestone, has crystalline limestone predominating as vein-matter, and some quartz is found subordinately. The surface workings show a very irregular vein; the walls are disturbed, and no definite line of contact can be established, which makes the vein appear 50 to 60 feet wide. Work was at first commenced on the outcrop by a cut on the side of the hill, following the vein nearly 100 feet on its course, and for 60 to 70 feet in depth. An incline of 40 feet has been sunk, and a tunnel of 270 feet length cuts the vein 65 feet below the surface work, or 175 feet below the outcroppings. The incline and tunnel show the vein improving in depth; its width in tunnel is 20 feet from the hanging wall (siliceous slate) to the foot wall, (compact bluish limestone,) and both are plainly discernible; the dip is 60° southwest. The ore in the surface workings occurred in irregular masses, seams, and pockets, varying from ½ to 10 tons in bulk, divided by slate and limestone; while in depth in the incline, it is found in more regular seams, and partakes of a more uniform character, ranging in width from 3 to 8 feet.

The ores from the mine belong to the second class, (copper ores,) although nearly all the described ores of the district occur in the vein; galena appears in the southern portion of the mine, but not in sufficient quantity for smelting operations without further addition of lead ores. Fifty feet below the mouth of the incline an assay of $178 32 in silver per ton, from an ore seam of 1½ feet in width, was obtained. At the time of Mr. Luckhardt's visit nine men were employed by the company, raising, daily, from 3 to 4 tons of ore to the surface, of an average value of $280 per ton. The capacity of the company's reduction works being 2 tons, daily, the product of the mine was limited to 4 tons. The appearance of the work done so far allows a daily extraction of 12 tons, and the opened ground shows about 1,200 tons of ore in sight of the above value. Local circumstances have thus far prevented the beneficiation of second-class ores, (from $80 to $50 ore,) of which there are over 2,000 tons now lying on the waste-dump.

Capital is only very lately finding its way to the district, and very sparingly. All operations done so far on the San Ignacio, and, in fact, on all the veins, have been only on a small scale, the district being but in its infancy, a state when all kinds of work are seldom carried on without great obstacles. But it has so far rewarded the owners handsomely for their outlay; and wherever it has been persevered in it has generally proven that great wealth is actually in the mines. In the vicinity of the San Ignacio are located the Bandera, La Primera, San Francisco, Alpha, Franklin, Asteroid, San Thomas, Coronel, &c., and other smaller veins, which bear not only in their formation but also in their ores much resemblance to the San Ignacio; but none of them have been explored sufficiently to reveal their absolute merit. All have yielded rich ores in small quantities.

San Lucas mine.—This mine is situated 6 miles north of the San Ignacio, and belongs also to the second class, namely, copper and silver mines. The croppings (quartz) dip 65° north, in limestone, and run east 5° south. Near the surface the vein shows 6 feet in width, containing several narrow and poor seams and spots of ore, and does not look promising. An incline of 94 feet has been sunk on the footwall,

and the vein followed 80 feet on its course, where ore has been found and extracted in bodies from 3 to 7 feet in width and 10 to 25 feet deep—the vein having widened to 13 feet from wall to wall. The lower workings show a decided improvement in the quality and quantity of the ore. The average of an eastern drift, in ore 5 feet wide, at 69 feet depth, was $58 83 in silver. The ore contains from 7 to 10 per cent. of galena, and some antimonial ores; gray copper and silver-copper glance predominate. I met with nests and bunches of ore assaying $300 per ton; and the ore lying on the company's dump, as it is being sent to the smelting-works, now averages $115 30 per ton. The mine has been very irregularly worked thus far. It is, like many others, very favorably situated for tunneling. A tunnel of 600 feet in length would meet the vein 350 feet below the outcrop; and I believe that with judicious management the mine could be made to yield 25 tons of $100 ore daily, with an outlay of $5,000, while the present yield does not exceed 6 tons daily.

In the vicinity are, among many smaller veins, the Wittekind, Belmont, Abundancia, Candelaria, San Miguel, Enterprise, Abellino, Virginia, Guadalupe, Guaymas, and others, some of which carry so little galena ores that they can be beneficiated by wet amalgamation. They all resemble the two veins above described, both in gangue and ores, yielding from $45 to $150 in silver per ton. Their widths vary from 5 to 40 feet, and thus far but little work has been done on them—just sufficient, in many cases, to comply with the laws of the district in order to hold possession, and I am of the opinion that, in all probability some of these mines, when once worked, will yield abundantly in ores, and will by far exceed the Ignacio and St. Lucas, which are already proven good mining property and looked upon as among the best in the district. One of my reasons for this opinion is that actual work has, in most instances, shown an improvement in depth both in quality and quantity. Another is the fact that the ore exists in bunches and pockets, which are detached from one another by barren vein-matter, or by intrusions of masses foreign to the vein itself. This leads me to expect more ore and larger bodies where less irregularities exist, which will be the case the deeper work progresses on the veins. These ore bodies are always found to be larger where much bulk of vein-matter exists than where a vein is narrow, and some of the above-named veins are very wide.

None of the described mines carry sufficient galena in their ores to fit them for smelting alone, neither can the majority of the ores be amalgamated; and as much attention has therefore to be paid to the lead as to the silver-copper mines.

The greater number of the veins located near the center of the district are so-called "galena ledges," as, for instance, the Union, San Felipe, Freiburgh, Nos. 1, 2, and 3, Santa Maria, Buena Vista, Knickerbocker, and others, some of which seem to be located on one and the same vein. I found three distinctly separated veins of very large dimensions, besides several smaller ones of little importance, on the hillside where all the above named claims are situated. With very few exceptions they are of a very uniform character, and in describing one all will be described.

The Union vein has a general north and south course, is imbedded in a compact grayish limestone, dips west 62° with the horizon, and carries calcspar as predominating vein-matter. Near the surface its width cannot be well established; it resembles a mass of ore thrown together with boulders of country rock to a width of 50 to 60 feet; only the foot-wall is visible in a few places. Several mining companies have located claims on this vein, and have attacked it from the surface to a depth of 130

feet in some places. The Santa Maria tunnel has cut the vein 200 feet below the surface. The lower workings show more regularity in the vein; its width can be called 23 feet, but in one place I saw it 40 feet; the foot-wall can be well seen, the hanging-wall can only be found well defined in places. It carries the ore in bodies of various sizes and dimensions, but they all have an inclination from north to south, and seem to improve southward. The ores are chiefly argentiferous galena; copper occurs only in very small quantities, and only near the surface. Iron pyrites, in various stages of decomposition, is a steady companion of the ores; it only exists where ore is found, and it is only where it is completely converted into peroxides that it has penetrated the vein-matter so as to hide the original texture and form entirely.

This vein has shown thus far three separate ore bodies, which have yielded to the various companies at work on them probably over 21,000 tons of ore, of an average value of $120 per ton. It has been attacked by two shafts and three tunnels, and is at present yielding all the necessary ore to supply three reduction works. Forty feet below the outcrop an average sample of the vein, here 30 feet wide, was taken regardless of waste, and $36 23 in silver per ton was obtained, and 87 feet below the outcrop the vein, 20 feet wide, assayed $58 11 per ton.

There are two phenomena which speak well for the future of the vein. The supposition is, that all veins change in depth, and especially when nearing the so-called water level. This change first shows itself in those ores which are easily decomposed, and requires the attention of the miner, as it influences the percentage of precious metals which the vein may carry in the croppings or surface workings. In the vein in question here we have argentiferous galena ores, accompanied principally by iron, and we find that a change has made itself already apparent at a depth of about 150 feet below the outcrop, namely, the galena has changed from a fine crystalline structure to coarse crystals, and the hydrated oxide of iron of the upper workings begins to resume its original state, *i. e.*, that of sulphuret of iron. The percentage of silver in the ore has, however, remained the same, and from this we may infer that it will probably remain so to a considerable depth.

On the surface the vein shows much irregularity. The intrusions of barren rock, foreign to the vein, which divide the ores in bodies, are very frequent. As depth is attained on the vein these intrusions still exist, but not in such multitude. The ore lies more regular, and we may expect to find more regularity in the occurrence of the ores as these intrusions decrease in depth.

A careful examination of the entire hill and nearly all the galena mines situated on it did not detect anything of sufficient import to destroy the opinion formed, namely, that a vast amount of argentiferous galena may be expected from them when they are fairly opened.

General remarks on mining and reduction.

A. Mining.—The larger portion of the mine owners at Cerro Gordo are in want of sufficient capital to open and explore their mines and to fit them for the extraction of large quantities of ores. This has been the main cause that mining has been carried on without a system. Many mines have only the necessary work done on them to make their titles good. Some of the mine owners seem to have worked solely with the object to extract a few tons of rich ore for sale, in order to produce the necessities of living, while others extract larger amounts of ore and try to smelt them under great disadvantages at or near the mine.

It is true they produce bullion, but they do not obtain such results as they ought to. This is partially caused by ignorance of the process of beneficiation by fire, partly by local circumstances. The actual product of the mines is nevertheless far in advance of the capital which has been invested in them.

The cost of mining the ores is from $3 to $3 60 per ton, but they are carefully assorted by hand at present, making the total cost of production when ready for the furnace from $5 to $12 per ton. The character of most of the mines and their situations are such that the mining cost ought not to exceed $2 50 per ton, as nearly all of them can be worked to a depth of 200 to 500 and even 600 feet by tunnels, obviating the cost of hoisting. The ores, except in the immediate vicinity of the surface, are surrounded by hard compact rocks, and their dip is such that but very little timbering will be required.

Labor at the mines ranges from $2 50 to $3 50 per day at present. These prices will probably maintain themselves for some time, but the cost of producing the ore will be greatly reduced as soon as the mines are opened in a systematic manner. Where two or three hands are needed now, a single miner will then be sufficient to perform the same work.

Most of the ores require blasting, and the final assorting ought to be carried on in the open air on the dump and not in the mines, as it is now done. The latter causes unnecessary expense and also loss in ore. A good illustration of this is, that in 1866 the ores in the Chollar Potosi mine, Virginia, Nevada, were assorted in the mine at and above the Potosi tunnel level, and a loss in ore occurred thereby; that in 1868 and 1869 the same ground was reopened and produced 23,000 tons of ore, which were assorted overhead and yielded an aggregate of $600,000.

B. Reduction.—At Cerro Gordo district three reduction works exist at present, none of which exceeds 10 tons working capacity. The one of Mr. Belshaw is the largest, and contains three furnaces. The other two are of 6 to 8 tons capacity. All of them work under great disadvantages from scarcity of water, which in winter has to be obtained by melting snow and ice to supply the steam-boilers, causing frequent stoppages. Besides these, several Mexicans own furnaces. They smelt their ores and refine their bullion on a small scale. In Lone Pine Valley exist three more establishments. The Cervantes Company reduction works of 20 tons capacity, driven by water power, is the best constructed. The Stevenson, of 10 tons, is situated at the east shore of Owen's Lake, and the works of a new company are being built of a capacity of 30 tons, on the lake, across which they will have a steamer crossing. Lone Pine Valley is certainly the place for smelting works, as sweet water and fuel are abundant, and ores from Cerro Gordo can be brought there at a cost of $7 50 per ton. It is only lately that the district has begun to yield regularly from $30,000 to $60,000 per month, except during one month when all the reduction works were producing, and $130,000 were shipped through to Los Angeles at 3¾ cents per pound.

Cupelling is not practiced, and all the bullion varying from $270 to $540 in silver per ton is shipped by land to Los Angeles.

The smelting done at Cerro Gordo and Lone Pine is carried out on the old Mexican method. The ores are assorted and freed from gangue matter as much as possible by hand at too high a cost at present. The galena ores are thrown into a "galemador," (a reverberatory furnace on an inclined plane,) where some of the sulphur and antimony is driven off and the greater portion of the ore is converted into a stiff slag highly impregnated with metallic lead. This is mixed with crude silver ores,

(the above-named copper ores, carrying copper and iron,) and smelted in a blast-furnace where the lead is reduced to its metallic state, carrying the greater portion of the precious metal with it. This is run into bars of 150 to 250 pounds. The Cervantes Company is the only one which has cupelling-furnaces.

These "galemadores" are generally 10 feet long, 5 feet wide, have from 22 to 36 inches between the bed and arch, and can slag from 6 to 8 tons of galena ores in twenty-four hours. They are heated with wood, and work without blast, and consume 2½ cords of wood per twenty-four hours. The "stack-furnaces" are of various shapes, round and square, from 10 to 15 feet high; their boshes vary from 18 to 25 inches in the clear. They are fed with wood, charcoal, and ore, in alternate layers, and require about 20 bushels of charcoal and ⅛ cord of wood to reduce 1 ton of ore. They reduce, according to their size and blast and the character of the charges, from 5 to 10 tons of ore per day. The cost of wood is from $6 to $8 per cord, that of charcoal 35 cents per bushel, in Lone Pine Valley. The price of both is much lower at Cerro Gordo. The smelting of silver ores, when lead ores are plenty, as is the case in Cerro Gordo, is a very simple operation, and at least 90 per cent. of the fire assay of the precious metal ought to be got from the ores, but at present only 50 to 55 per cent. are obtained in Cerro Gordo. Many here adopt the principle to produce their lead with as high a percentage in silver as possible in the stack-furnace, which is not judicious, and the low yield in percentage of the assay is, in part, directly attributable to this. But the bad proportion of the blast, and the very shape of the furnaces, exert also considerable influence in this direction.

Cerro Gordo is a new district, the actual merit of which has not been made apparent for want of capital and energetic explorations. There are a great many mines, among which is a comparatively large number of excellent ones, and little as they have been opened the developments already made promise a bright future. The character of their ores is such as to render the extraction of silver comparatively easy; moreover, Lone Pine offers every facility for profitable smelting, and there is no apparent reason why in time the district should not stand as high in rank as many others who had the advantage of capital.

The product of this district during the last year does not fall short of $300,000, and there is every prospect that it will rapidly increase. Indeed, in August, 1870, the production of the Balshaw furnace alone was 2,774 bars, or 238,728 pounds of lead bullion; mining, especially tunneling, was going ahead rapidly, and the prospect was that a large amount of stoping-ground would be ready to be attacked in a short time.

The Caso district, also situated in Inyo County, should be briefly mentioned here. This locality is fifty-five miles from Lone Pine. It was abandoned in 1866 on account of the Indians. In 1868 a party of Mexicans settled there, and have now twenty arrastras at work. The ledges are small, and mostly lie flat, but are very rich. The greatest abundance of ore is found in the Mina Grande, formerly the Josephine. The gold bullion produced is worth $15 per ounce, and the product between April and October is estimated at between $30,000 and $40,000. The Golconda Mine, two miles from Owen's River, was located twenty years ago, but little work was done. A thousand tons could easily be taken out in a short time, if a small amount of capital would be invested. As yet none has found its way to this district. The total population of the county, according to the late census, is 1,956; Chinese, 29.

MONO, KERN, LOS ANGELES, AND TULARE COUNTIES.

Of these counties a few brief notes only can be given, mainly from the reports to the Census Bureau. The ores of Mono County are eminently silver ores, but contain some gold. Five mines, employing twenty-two men, were reported working June 1, and the total yield for the preceding year was $95,000, of which $83,500 was silver. The wages paid were $83 per month.

From Kern County three quartz mines were reported working.

The Delphi Mining Company has a shaft 280 feet deep, and a tunnel 450 feet long, and employed eighteen men during one month, paying out $1,500 for wages. The product was 260 ounces of gold, worth $3,500. La Esperanza is worked by a tunnel 200 feet long. It was worked with fifteen men during seven months, at a cost of $8,400 for wages and $3,180 for materials. The product was 900 ounces, worth $12,600. The Kern River Mining Company works its mine by a shaft 170 feet deep, and a tunnel 260 feet long. During the entire year twenty-nine men were employed, and $27,000 was expended for wages, while the materials used amounted to $3,200. The total product of this company was $35,000.

From Los Angeles County a single quartz mine is reported working during the entire year. This is the mine of the Eureka Mining Company, at Solidad. Thirty to forty men were employed at different times, and $48,000 expended for wages. At the mine is a shaft 125 feet deep and a tunnel 150 feet long. The total product was $50,000.

All the figures in regard to product above introduced, as well as the following, refer to the year ending June 1, 1870.

In Tulare County the 10-stamp mill of Birdseye & Co. on White River is reported to have been in operation during five months. Five men were employed at a cost of $1,500 in wages, and $700 were spent for materials. The product was 250 ounces of gold, worth $4,000. I am not informed in regard to the mine from which the ore crushed by the mill was taken.

The total population of these counties is as follows:

	Total.	Chinese.
Mono	430	42
Kern	2,925	43
Los Angeles	15,309	234
Tulare	4,521	99

MARIPOSA COUNTY.

The principal quartz-mining enterprise in this county continues to be that of the Mariposa Company, upon the grant of the same name. The history of this famous estate has been marked with many vicissitudes, brilliant successes having alternated in its management with disappointment and loss. The conditions now surrounding the enterprise are in many respects more favorable than ever before, as I can testify from personal observation at the time of my last visit, November, 1870. The rate of wages is more reasonable; Chinese miners are employed, even underground, to a considerable extent, with satisfactory results, and without violent opposition from their white colleagues. The machinery of reduction is complete and efficient. At the Ophir or Benton mills, where sixty-five stamps were running, and thirty more in process of erection,* there is an excellent water-power secured by a dam which

*The whole number running at these mills in March, 1871, was eighty. A new water-wheel will be required before the other fifteen are started.

may be trusted (in spite of sundry former catastrophes) not to wash away again; the mills themselves have been remodeled, raised, furnished with California high-mortar batteries, and arranged to work both cheaply and effectively. The Benton mills used to have the reputation of crushing more cheaply and losing more gold than any others in the State. In their present form the desirable characteristic appears to have been retained and the other removed. All the product of the Josephine and Linda (formerly Pine Tree) mines is worked at these mills with a profit, as the statement below, taken from the books, will show.

Another great improvement is visible in the general economy of administration, and in the absence of the turbulent and lawless class of inhabitants which once gave Mariposa an unenviable fame. The "roughs" have shot one another, emigrated, or been hanged; and the departure of these worthies, coupled with the termination of legal conflicts, has greatly assisted the management of affairs with undisturbed attention to the permanent welfare of the estate.

The three mills at the river, called as a whole the Ophir (formerly Benton) mills, have the following strength: Lily, (upper mill,) 16 stamps, at 650 pounds; Ada, (middle mill,) 25 stamps, at 550 pounds; Bessie, (lower mill,) 24 stamps, at 500 pounds. The Ada is considered the best mill. All the batteries are run at 65 to 70 drops per minute, and the total crushing capacity of the 65 stamps is about 60 tons daily.

The ore is supplied from the Pine Tree and Josephine mines. The average of five semi-monthly cleanings-up on Pine Tree ore, during August, September, and October, 1870, was $10 50—or, leaving out the second clean-up of September, when a lot of poor ore was treated, the average was $11 35 per ton. No account is taken of tailings or sulphurets in this statement. A similar examination of the books as to Josephine ore showed an average yield of $8 06 per ton. The amount of rock crushed from May 1 to October 1, 1870, was as follows:

Month.	Bessie.	Ada.	Lily.	Total.
May	578	610	499	1,689
June	505	619	542	1,666
July	528	654	488	1,670
August	536	525	451	1,512
September	559	499	261	1,319
Total	2,706	2,907	2,241	7,834

About one pound of quicksilver is employed to ten tons of rock, and 35 to 40 per cent. of the quicksilver is saved in amalgam, worth $8 per ounce.

That the foregoing yield is sufficient to leave a small margin of profit appears from the following estimates of expense at the Josephine and Linda mines:

Per ton.	Josephine.	Linda.
Mining cost	$2 75	$5 00
Transportation	75	75
Milling	2 25	2 25
General expense	1 00	1 00
	6 75	9 00

The greater cheapness of mining in the Josephine is due to its immense stopes, and the manner in which it is opened by drifts from the face of the mountain. The Linda, however, furnished during the months referred to a better grade of quartz, principally, I believe, from the so-called "Garden" shoot, which has been opened in that mine at greater depths with excellent results. The average thickness of the vein in the Linda being about 5 feet, and in the Josephine 10 feet, the work of opening new ground is but trifling, since every foot of drifting exposes for extraction a large amount of quartz. I measured the reserves of ore in these two mines, including only what could be extracted without dead-work in sinking or drifting, and found in the Josephine 15,810 tons, and in the Linda 14,016 tons. At the same time, the quality of ore in both mines was improving, and the yield at the mills in November was higher than the averages above reported. By the enlargement of milling facilities, and the treatment of a greater amount of ore, the milling cost at the river could be reduced to $1 75, and the general expenses to 50 cents per ton of rock, thus securing $1 per ton of additional profit.

The Mariposa mine contained, likewise, immense reserves of low-grade quartz. The mill at Mariposa has been reduced to 25 stamps, and the operations of these for August, September, and part of October, 1870, showed an average yield of $9 98 per ton. This scarcely paid expenses, as the mill is run by steam; and the mine has since been temporarily closed. When reopened, it will be worked by Chinese labor exclusively, as it has been, in part, the case for a long time past.

The old Princeton mine, in which the population of Mariposa County still place much affectionate faith, produced from a single large body or chimney of ore between four and five million dollars. This chimney was worked to a depth of some 600 feet, and it was officially reported to be exhausted just before the first grand collapse of the Mariposa Company. A complete sectional map of the workings came into my possession several years ago, bearing valuable memoranda as to the yield of the quartz from each stope; and this, with other evidence, led me to doubt whether the old Princeton chimney was really exhausted, and to suspect that the company had been too easily discouraged. Subsequently to the first abandonment, however, a creditor took the mine and gutted it, filling up the deep shafts with refuse, to save hoisting, taking out pillars and timbers, and leaving the workings in such a condition that no one would like to undertake the job of reopening them. Whether that chimney is or is not exhausted will, therefore, not be soon discovered. Many explorations were made, without success, to find some equally promising body of ore on the continuation of the vein. It seems to part near the mine into two branches, in going eastward; and these are said to reunite toward Agua Fria, a mile away, inclosing between them a large area. On the northerly branch operations were unsuccessful, though this was generally supposed to be the main vein. The southerly vein makes a violent bend on the top of the first hill east of the mine, and trending northeast crosses a ravine, a smaller hill, and another ravine, beyond which the outcrop is hidden in the chapparal. On the top of the smaller hill are the two shafts of the New Princeton, the discovery of which was the most significant event of the year for the estate. The connection between these and the old mine is distinctly established by innumerable exposures of the vein outcrop.

There is not much to be said of these shafts, but what there is is highly important. The western one is a prospecting shaft, 60 feet deep at the time of my visit; the other, 200 feet east, is a large working shaft, then about 30 feet deep, and showing a vein of 5 feet, the foot-

wall half of which is certainly very rich rock. I made several pannings, indicating, I am confident, as much as $30 per ton of free gold; but of course I cannot feel sure that the samples were a fair average, though they were not the best that I saw, or could have taken out from the vein myself. More important, in my opinion, is the general structure of the vein and the appearance of the quartz, which is identical with that of old Princeton in its prime. Taken in connection with the known character of the Princeton vein, upon which it undoubtedly is, the indications it presents are such as to warrant even the sanguine expectations of the old residents of the neighborhood. The old Princeton mill is to be refitted and started early in 1871, with 25 stamps, on the ore from this mine.

This discovery shows how much might be accomplished by judicious prospecting on the estate. The number of quartz veins not yet tested is very great, and the richness of the placers at many points indicates the existence of valuable lodes in the neighborhood. The Guadaloupe region, not worked at all by the company, contains numerous rich (though narrow) lodes. Some of them are worked on royalty, but there is no capital invested there. I understand that one of these lodes, the Buckeye, which has paid well hitherto to operations under a lease, will be worked this year by the company.

In further illustration of the reduction of wages, the following comparative statement of the average daily wages paid during three different periods, kindly furnished by Mr. J. G. Rice, the assistant superintendent, is presented.

	From 1863 to 1865.	1865 to 1868.	1868 to date.
Miners	$3 50 to $4 00	$3 25 to $3 50	$3 00
Strikers	3 00	2 75	$2 25 to 2 50
Carpenters	4 00 to 6 00	4 00 to 5 00	3 50 to 5 00
Blacksmiths	4 00	3 75 to 4 00	3 25 to 3 75
Machinists	4 00 to 4 50	4 00	3 50 to 4 00
Engineers	3 50 to 4 00	3 50	3 00 to 3 50
Firemen	2 75 to 3 00	2 75	2 50 to 2 75
Mill-tenders	3 50 to 4 00	3 50	3 00 to 3 50
Mill-feeders	3 25 to 3 50	3 25	3 00
Laborers, (white)	2 50 to 3 00	2 50	2 00 to 2 50
Chinese strikers	....	1 75	1 62 to 1 75
Chinese laborers	....	1 50	1 50

The item of wages being at least two-thirds the whole cost of mining and reduction, it is evident that a general average reduction of some 25 per cent. in that item is no insignificant matter, in the treatment of low-grade ores especially, and in the execution of "dead-work" and new constructions.

Thanks are due to Mr. Thomas Goodsell, the company's superintendent, for much courtesy and valuable assistance.

The following data, however, are not from the company or its officers: The total production of bullion for the fiscal year 1869-'70, from the Josephine, Linda, and Mariposa, was about $170,000. I judge that the production for the calendar year 1870 was about $200,000. This is a satisfactory increase of 100 per cent. on the product of the previous year, and a similar steady improvement may be looked for in 1871. The process of building up a large business upon the basis of low-grade ores is a slow one, but the result is much more permanent than the brief though brilliant prosperity of "rich" mines.

In the latter class may be ranked the Oaks and Reese, to which allusion has been made in former reports. This mine was on a very narrow and hard vein, and was abandoned last year by the company in spite of the extraordinary richness of occasional lots of ore. It is reported that the miners, going back to the work after the company's operations had been suspended, soon struck upon another pocket of free gold, and made a handsome profit by the operation. The story is highly probable, though I do not vouch for its truth. It is quite common for skillful miners, when they foresee the suspension of operations, to conceal the occurrences of rich side-shoots, or pockets, &c., with a view to save them until permission can subsequently be obtained to work the mine on a favorable lease, or to pay back-arrears of wages. Accordingly, when the workmen who have been employed in a mine undertake to carry it on after the owners have stopped, the first thing heard of is frequently a fortunate discovery of rich ore. But this was known to some one beforehand, or the speculation would not have been undertaken. I am not aware that miners, working in this way by themselves, for a long period, and opening new ground, have better luck than other people.

The Washington mine, about two miles north of Hornitos, is reported as steadily successful. The shipments of bullion in the autumn of 1870 were about $12,000 per month, and had previously been $15,000. For the year ending June 1, 1870, the product is given at only $50,000. I presume this is due to the fact that the mill and chlorination works were not running at full capacity—the latter not at all—during a large part of the year. The mill has now 30 stamps running. The ore is heavily charged with sulphurets, which are successfully treated in the chlorination-works erected for the company by Mr. Deetkin, of Grass Valley.

The Quartz Mountain mill, of 20 stamps, was idle in June. In November it was working ore from the Flint Peabody mine, two miles south of Hornitos.

The Mount Gaines Company, five miles east of Hornitos, was producing at the same period about $2,000 monthly. The 20-stamp mill works both custom ores and those of the company's mine, in which rich sulphurets are said to have been discovered.

I am indebted to Mr. Thomas Goodsell and to Mr. John R. Hite, the owner, for the following notes on the Hite mine, which is located near the geographical center of Mariposa County, on the summit of the elevated ridge between and quite near the intersection of Merced River with the South Fork of the Merced. The course of the vein is nearly east and west, and the dip about 80° north. It is irregular in width, varying from 3 to 11 feet, and richest where widest. The average yield of the wider portions is $27 per ton; of the narrow, $13 per ton. There are two shafts, down 300 feet. The first level is 200 feet below the surface, with a drain-adit crossing the strata coming in from the south or South Fork side. Above this level the ground is mainly stoped out. Both the east and west shafts are down 100 feet below it, and drifting is going on to connect the shafts, the east drift being in 300 feet from the shaft, and the west drift 30 feet, leaving a distance to connect of 260 feet, as the shafts are 600 feet apart. A new tunnel is driving from the side of South Fork to strike the vein 850 feet below the surface. It is now in 850 feet, and will be 1,250 feet long when completed. It approaches the vein at right angles. The vein is intermixed with thin layers of black soft slate, like the country rock. There are three ore-shoots in the ground already opened, of which the most westerly is the poorest. The vein is continuous for a long distance, running nearly parallel with the Merced River.

The mill is situated on South Fork, whence it obtains a water-power of 42 feet fall. A Tyler turbine gives 150 horse-power. There are 20 stamps, of 550 pounds each. The gold is very fine and is saved with difficulty, owing to the creamy consistency of the slimes. The method followed is to amalgamate in battery, discharge into pans, riffle-boxes, &c., and save the sands below, as they contain a large percentage of gold. The distance from the mine to the mill is some 2,000 feet, the mine being above the mill some 1,500 feet. The distance from Mariposa is eighteen miles, by a good road to the summit opposite the mill, whence there is a very abrupt and difficult descent to the bottom—say 2,000 feet in half a mile. The present estimated value of the mine and improvements is half a million dollars. The water-power is ample for the present mill for ten months in the year. Timber is obtained within five miles of the mine. The workings are dry, but owing to the softness of the walls heavy timbering is required. No "deads" are left, as all the vein is taken out for crushing. The product of this mine for the year ending July 1, 1870, was not far from $180,000.

Of placer-mining operations in Mariposa County there is little to be said. The aggregate of gold from this source during 1870 will probably not exceed $25,000.

TUOLUMNE COUNTY.

No change of importance is reported to me in the mining industry of this county since last year.

Little hydraulic mining has been going on, only four claims being reported in operation. These employed six men on an average of ten months, at about $60 in wages. Water costs from 8 to 10 cents per inch. The total product of these claims for the year ending June 1, 1870, was $20,000, making the average yield per hand per day of this class of mines $12 65; which must be considered as very good returns. The claims producing the most were those of Spalding & Co., which yielded $5,400, employing two men ten months, and of Hayner & Co., which yielded $10,200, employing the same number of hands during the same time.

Eight quartz mines have been worked during the year, and in these sixty-seven men were employed an average of 8.7 months, at about $3 per day. The whole product for the year ending June 1, 1870, was according to the returns of the mills, $165,900, or about $13 82 for each ton of ore worked. The following mines produced: Eagle, 2,500 tons; Golden Rule, 3,000 tons; App, 2,000 tons; Heslep, 1,900 tons; Reist & Co., 1,425 tons; Mount Jefferson Company, 1,400 tons. The principal mills reduced ore as follows: The Eagle, 2,100 tons, yielding $31,500; the Golden Rule, 2,600 tons, $38,500; the App, 1,600 tons, $23,000; the Heslep, 1,500 tons, $26,000; Reist & Co., 1,200 tons, $13,000; Mount Jefferson Company, —— tons, $21,500.

The following description of some of the mines of this county, taken from the San Francisco Scientific Press, will prove interesting: "The App mine, on Quartz Mountain, near Jamestown, and some 6 miles from Sonora, is owned by Griffing & Totten. The ledge is 1,000 feet long, and from 15 to 30 feet wide. They have a 25-stamp mill crushing 15 tons per day, but with a capacity of crushing 25. Some twenty men are employed. They are now further developing the mine, the reason of not running to their full capacity. Their rock will run from $15 to $20 per ton. They have a shaft down 580 feet, on an incline of 60°.

The hoisting works are very complete, and run by an engine of 25 horse-power.

"The Heslep, next adjoining the App, and parallel with it, separated only a few hundred feet by an immense horse, is owned and superintended by B. F. Heslep, esq. This ledge is well defined, 14 feet wide and 1,650 feet long. Mr. H. has a 15-stamp mill, run by water-power—40-foot wheel. His tunnel is in 700 feet on a water grade. At this point it is 170 feet to the surface. Nine men are regularly employed, crushing 15 tons per day, (twenty-four hours,) and the rock averages $5 per ton.

"The Knox mine, ½ mile from the Heslep, and midway between this and Poverty Hill, is 1,200 feet in length, with about a 20-inch vein. It is owned by Green, Jones & Preston. They have hoisting works run by a 30 horse-power engine, and a mill of 10 stamps and 2 arrastras, now crushing 7 tons per day. They employ fifteen men, and have lately introduced giant powder to expedite their supply of rock, as they are not running to their full capacity. They claim to get an average of $35 per ton out of their rock, exclusive of sulphurets.

"The Golden Rule, ¾ of a mile beyond Poverty Hill, and about 7 miles from Sonora, is owned by a joint stock company, principally of San Francisco. A. S. Phifer is its superintendent. The mill of 15 stamps is run by water-power, (50-foot wheel,) and is now crushing 15 tons per day, (twenty-four hours,) which average $10 per ton; sixteen men are employed. This mine was originally owned by a company of Italians, and was first struck in 1863. A tunnel 500 feet in length is run in on a grade with the mill, to which the rock is brought by car. This tunnel runs nearly east; at this point the tunnel runs south 75 feet, where their hoisting works are situated, 87 feet under ground. It cost $36 per foot to run it. The hoisting works are run by an engine of 12 horse-power. At the hoisting works there is a vertical shaft 225 feet deep from the surface. The hanging wall is of serpentine, and the foot wall of feldspar formation. The vein is from 7 to 9 feet wide, and is nearly 90 per cent. slate. Free gold is found in each of the above-named formations often 4 inches deep in the foot wall, which goes to prove the old Forty-Niners' saying, that gold is just where you find it. The company consume about 25 pounds of giant powder weekly for blasting purposes. Their sulphurets pay them about $40 per ton."

The population of this county, according to the last census, is—total, 8,150; Chinese, 1,523.

CALAVERAS COUNTY.

The mining enterprises of this county have been prosecuted with energy during last year. The product from hydraulic shallow placer and quartz mining amounts, according to the returns to the Census Bureau, to $1,080,000 for the twelve months ending June 1. Many shallow-placer claims have been actively worked, but the majority are small affairs, on which all the work is performed by the owners themselves. On 236 claims reported 684 hired men were employed on an average of 7.31 months. Besides these about 250 owners spent an average time of 8.6 months on their claims. The yield per hand per day was low, being $2 57 on an average. Total wages paid, $250,300. The total materials consumed had a value of $109,600. The price paid for water has generally been 10 cents per inch, and the average wages amounted to $50 per month.

The total product of this branch of mining in the county is reported

as a little over $500,000. The largest returns were received from the following claims: Railroad Company, $15,000; Texas Company, $30,000; Paul & Co., $12,000; Crehr & Co., $15,000; Gleason, O'Neil & Co., $10,000; Henry Connelly, $10,000.

Of hydraulic claims 46 are reported. They yielded about $180,000, of which amount the following claims gave the highest yields: Bomig & Co., $15,000; Strong & Mathews, $10,000; Leckerman & Co., $12,000.

The quartz mining enterprises of the county are mostly small and a limited amount of capital is invested.

The prices of labor, lumber, and charges for milling during the year, have not varied much from those given in my last report, but it is evident that a tendency to lower the wages begins to gain ground.

Thorp & Co.'s mine was worked by two men during the entire year, and the quartz was worked in their three arrastras. These are driven by a 24-foot water-wheel. They have a flume connected with it 200 feet long. Two men worked in these reduction works and crushed, in twelve months, 450 tons of quartz, which yielded 187 ounces of gold, valued at $3,000.

John Bachman's mine was worked by two men during six months. They took out 200 tons of quartz, valued at $1,000.

A. Acerford's mine has a shaft 90 feet deep. Two men raised, in six months, 150 tons of quartz, valued at $1,200. The ore is raised by windlass.

The Union lode, 5 feet wide, was worked by three men throughout the year; 400 tons of quartz were raised, valued at $5,000. The shaft on this mine is 150 feet deep. The mill of the same company, ten stamps driven by a 20 horse-power water-wheel, crushed this ore and also some custom-rock, producing with nine men in eleven months $1,700.

The following are some of the mines worked during the year:

Reed & Co.: Shaft 80 feet deep; two men took out 200 tons in six months, valued at $1,600.

Davis: Shaft 90 feet deep; ores raised by whim; three men took out in six months 500 tons of quartz, valued at $3,000.

B. K. Thorn & Co.'s mine has two shafts, 85 feet each, from which four men extracted 600 tons of quartz in six months. Value, $3,000.

Quaker City: Shaft 150 feet deep; ores raised by horse-whim; six men took out 1,200 tons in twelve months. This ore was worked in the same company's mill, a 10-stamp mill, driven by a 30 horse-power engine and yielded 350 ounces of gold, worth $6,000.

Joseph Lafay's mine: Shaft 160 feet deep. One thousand eight hundred tons of quartz, valued at $9,000, were taken out during the year.

Barry, Frank & Co.'s mine has a tunnel 300 feet long and a shaft 90 feet deep. Five men raised, in twelve months, 400 tons of quartz, worth $17,200.

Besides this, the following mines and mills were in operation:

Gold Mountain Company worked its 5-stamp mill, driven by 8 horse-power engine, for three months with ten hands, and produced $6,600.

Reserve Company has a 20-stamp mill, driven by a 30 horse-power water-wheel. Produced, in eight months, employing nine men, $7,000.

The Finnegan Mining Company ran its 5-stamp mill, driven by an 8 horse-power engine, for a short time with two men, and produced only a little over $300.

Angel's Quartz Mining Company produced $48,000. This company employed fifty men for eleven months.

Garret & Co. crushed 1,800 tons of cement, yielding 337 ounces of gold, valued at $5,400. Their mine has a tunnel 300 feet long and a

shaft 50 feet deep. The 5-stamp mill is driven by a 20 horse-power over-shot water-wheel.

Bouckell & Co. employed twelve men throughout the year in their mill and mine. The former has 5 stamps driven by a centrifugal water-wheel, and a flume, 600 feet long, is connected with it. The product was 837 ounces, valued at $15,000.

The Golden Gate Mining Company have a tunnel 450 feet long. Their 6-stamp mill produced, with twenty men, during twelve months, 1,350 ounces of gold, valued at $20,000.

Gwin & Coleman have a 35 horse-power hoisting and pumping engine at their mine. The shaft is 300 feet deep and four levels are run from it. From these they took 9,000 tons of quartz with twenty-eight men in twelve months. This ore was worked in their 16-stamp mill, which is driven by a 30 horse-power water-wheel. Besides the stamps it contains two pans and one concentrator. Seven men were employed for twelve months. The product was 3,000 ounces of gold worth $48,000, and 50 tons of concentrated sulphurets valued at $4,000. These sulphurets, together with others, were worked in chlorination works, which were erected for custom work by a firm whose name is not given by my agent. The works consist of a concentrator, one furnace and the necessary vats, precipitating vessels and generator. They employed five men for six months, and treated altogether 200 tons of sulphurets, which yielded 800 ounces of gold valued at $16,000.

Rathgeb & Co.'s mill, containing five stamps and one pan, driven by a 25-foot water-wheel, employed two men for twelve months and produced $5,000.

Alexander & Co.'s mill, containing two centrifugal water-wheels of 25 horse-power, together driving ten stamps and two pans, worked the ore from the company's own mine. Twelve men were employed in the mine and mill for twelve months, and the product was $20,000.

Chas. Clacklin & Co.'s mine is opened by a shaft 140 feet deep, and a tunnel 200 feet long. Eight men took out, during twelve months, 4,000 tons of quartz, which were worked in the company's 15-stamp mill and yielded 1,250 ounces of gold worth $20,000. The mill has also three pans, the whole being driven by a 20 horse-power engine, and six men were employed throughout the year.

Albert Lazy has worked a crusher and two grinders, and produced $10,000 from 500 tons of quartz.

John F. Henry's mine has a shaft 150 feet, with whim for raising the ore. Three men were employed for six months and took out 100 tons of quartz. His mill contains eight stamps, one pan and one concentrator, all moved by a 25-foot water-wheel. Two men were employed for twelve months and 1,500 tons of quartz reduced. The product was 1,875 ounces of gold worth $30,000.

Besides those mentioned, many smaller quartz mining enterprises were in operation during part of the fiscal year, and the total product of this branch of mining may be safely estimated at not less than $340,000.

The population of the county is, according to the late census: Total, 8,895; Chinese, 1,432.

AMADOR COUNTY.

Quite a number of hydraulic claims are reported as having been in operation, but most of them were carried on by the owners themselves, who employed very little help. The sixty claims reported gave employment to 223 men for an average of 7.2 months, and the total product

was about $125,000. Exact returns of yield I have been unable tc obtain, but the figure indicated is not taken too high. The yield of these mines per day per hand has been low for several years past, and did not exceed $3 last year. The price paid for water was 5 cents per inch.

An unfortunate fire in the principal shaft of the Amador mine in the month of April, 1870, caused a suspension of mining operations for four months. The following figures taken from the secretary's report for the calendar year 1870 give the most important items connected with the business of the company: "The receipts for the year from all sources were $341,701, including $301,533 from the proceeds of ore. The disbursements were 341,437, including $111,000 in dividends to stockholders, $98,298 for construction of shaft and improvements, $63,405 on mine account, and $20,887 for general expenses."

Besides the Amador, the Keystone, Oneida, Potosi, Lincoln, and Marklee mines have been worked. I estimate the yield of these mines for the year ending June 30, 1870, as follows: Keystone, $300,000; Potosi, $12,000; Oneida, $128,000; Lincoln, $30,000; Marklee mine, $20,000.

Four hundred and fifty-six men were employed in eleven quartz mines, which were in operation for an average period of eleven months. The wages paid are about $75 per month.

Only thirty-seven placer claims are reported in operation, and the yield per day per hand is little over $2, hardly wages; two hundred and seven men were employed on these claims on an average of 7.6 months, and many of those working were owners. The total product was less than $50,000. Water has been sold throughout the year at prices varying from 3 to 5 cents per inch.

The population of the county, according to the census of 1870, is: Total, 9,582; Chinese, 1,629.

PLACER COUNTY.

Both hydraulic and placer mining has been carried on actively and with good results. The quartz mines so far worked have yielded small returns, and the business is not very encouraging. The reports from fifteen placer claims, worked during 8.88 months on an average, give $176,000 as the yield for the year ending June 1, 1870. One hundred and forty-six men were employed at about $60 per month, and the average product per day per hand was $5.

The Mountain Company, the only one which works in the "back channel" at Forrest Hill, has 2,300 feet of main and 1,700 feet of branch tunnels completed, and produced $40,000; the Mountain Gate Company, with 3,100 feet of tunnels, produced $35,000; the Morning Star, $20,000; and the Cañon Creek Company, $12,000.

The total product of twenty-one hydraulic claims in operation in this county is reported as $385,000. They gave employment to one hundred and sixty-two men, who were employed for 6.25 months on an average. The average yield per day per man was $14 50, and the wages paid were from $70 to 75 per month.

The largest returns were received from the following claims: Pond & Co., at Todd's Valley, $25,000; Van Emon Bros., $35,000; Harkness Company, $34,000; Indiana Hill, $14,000; Gosling Ravine Company, $30,000. These hydraulic claims, according to the returns per day per hand above mentioned, must be ranked among the richest in California.

Few quartz mines were in actual operation. The product of the five mines reported amounts in the aggregate to only $58,000 for the year ending June 1, 1870, and the operations seem to have left little profit.

These mines employed sixty-two men on an average of 10.4 months, paying average wages of $64 per month. The Rising Sun has again been the leading mine; thirty-five men were employed throughout the year, and the product was $24,000. The Golden Gate took out in twelve months $12,000, and Staples & Co. $17,500. Many of the mills in this county have been idle throughout the year.

It should perhaps be recorded here that in this county, on Rattlesnake Bar, a piece of gold quartz was found by a miner in the month of July, which weighed 106 pounds, and of which 97 pounds were almost pure gold; the whole worth over $25,000.

The population of the county, according to the late census, is: Total, 11,357; Chinese, 2,409.

EL DORADO COUNTY.

The yield of gold in this county has been about the same as last year.

Placer-mining, both surface and hydraulic, has not experienced any improvement, and the yield per day to the hand is low.

There are sixty-four shallow placer claims reported in operation during nearly seven months previous to June, 1870, and 221 men were furnished with employment in the same. The average wages paid were about $60 per month. The claims producing the highest amounts are the following:

The Deep Channel Mining Company at Placerville, employing five men throughout the year, produced about $6,500; the Cedar Springs Company, employing seven men during four months, produced $7,000; and the Falls Mining Company at Columnas, employing ten men, during eight months took out $13,500. The remaining claims yielded, nearly all, much less than those named, and the total product of all does not exceed $120,000. The average yield per day per hand was less than $3.

Of the twenty-one hydraulic claims reported, none produced over $20,000 and the total product amounts to $90,000. These claims were worked by 89 men during an average season of 8.6 months. The average wages paid have been about $65 per month, and the average yield per day per hand is $4 90.

The following claims have been the most prosperous, and for the year ending June 1, 1870, produced the subjoined amounts: Excelsior Mining Company, Placerville, employed twelve men for twelve months, $19,000; Hook and Ladder Mining Company, Placerville, employed four men for twelve months, $9,000; Nip and Tuck Mining Company, Placerville, employed five men for twelve months, $10,000; McKenney & Co. employed three men for six months, $6,000; Davenport & Co. employed three men for twelve months, $9,300.

The report of the quartz-mining claims comprises fifteen mines, which were in operation the whole or part of the year, and on an average 6.75 months. They employed 90 men at average wages of $75 per month.

The total product of all these claims I estimate at $120,000, and the following are credited with the highest yields: Crystal Gold Mining Company, employing fifteen men nine months, $10,000; Sheppard & Wilton, employing eighteen men six months, $29,000; Havilar Mining Company, employing twenty men nine months, $44,000; Confidence Mining Company, employing five men twelve months, $7,000.

The tendency to reduce wages has asserted itself in this county as in almost all the other older mining localities during the year.

The population of the county, according to the late census, is: total, 10,309; Chinese, 1,559.

NEVADA COUNTY.

Quartz and hydraulic mining operations as well as prospecting have been more active in this county than in any other of the State. Especially quartz mining was very successful.

The shallow placer mines, although to a great extent worked over, some of them several times, have nevertheless furnished employment for a considerable number of miners, many of whom were Chinese. But this interest, as well as hydraulic mining, has suffered greatly from want of water during the summer and fall.

The total yield of thirty-four placer claims for the year ending June, 1870, is reported at a little less than $100,000. These claims employed 302 men on an average of 5.4 months, and yielded $12 59 per day per hand. They are scattered over the whole county, but the more prominent ones are reported from Rough and Ready, Little York, Grass Valley, Bridgeport, and Nevada. The most prominent of these claims, as far as their yield is concerned, are that of the Swamp Angel Company at Little York, which yielded in twelve months, with the labor of six men, $14,000; and that of Peabody & Hall, at Nevada, which produced an equal amount. Thirty-one hydraulic claims are reported to have been worked by 235 men an average of 7.5 months. The average wages paid were $78 per month, and the average yield per day per hand was $8 40. Charges of the water companies to these claims varied from 7 to 12½ cents per inch, according to the locality. The total yield of all the hydraulic claims during the year ending June 1, 1870, was about $380,000.

The following claims are distinguished by their high yield: W. H. Dureas, Little York, employing twelve men for five months, $31,000; E. Williams, Little York, employing ten men for nine months, $26,000; Little York Mining Company, Little York, employing forty men for nine months, $91,325; Union Gravel Mining Company, Bloomfield, employing fifteen men for twelve months, $30,000; R. C. Black, Bloomfield, employing ten men for five months, $18,500; Q. D. Hickeye, Eureka, employing nine men for nine months, $17,000; Omega Water Company, Washington, employing twenty men for ten months, $65,000; W. M. Eddy, Bridgeport, employing fifteen men for twelve months, $35,000; Sailor Flat, Nevada, employing two men for five months, $9,000.

In the fall gravel mining seemed to come into more prominent notice, and several new enterprises were started, and old mines taken up again.

In August, Messrs. Eddy, Bell, and others had about perfected arrangements for running a tunnel from the South Yuba side of the ridge to their claims near French Corral. The tunnel will be 2,000 feet in length, having a width of 10 feet, and will be run on a level to drain all of Empire Flat, and the most of Kate Hays Flat. The tunnel will open a bed of rich cement gravel 40 feet in depth and covering many acres in area. The projectors have had offers from reliable parties to run the tunnel for $15 a foot, and they may probably get the work done at a less rate than that. The intention is to have two flumes put down the entire length of the tunnel, and extend them as far beyond the mouth as may be desirable, as there is plenty of fall for dumps and under-currents. By this means they calculate that the cement, which they have been crushing in stamp-mills, will be completely disintegrated and the gold set free. The enterprise is one of the most important in its prospective results of any ever undertaken in the county. The ground opened would probably yield a great deal of gold.

A little later in the fall it was reported in the press, that Randolph Hill, or Alta Hill, (for these names are applied to different parts of the

same contiguous ridge,) was worked systematically and scientifically, from one end to the other, a distance of about four miles, and with the most flattering prospects of success. A number of "diggings," to be worked by the hydraulic process, as well as by drifting and raising gravel to the surface to be washed, were soon to be opened. The claims located at the western point of the hill, on the north side of it, are those of McSorley & Co., and on the south side of the hill are the claims of Gilham, Macauley & Co. Both sets of claims have been strongly prospected, and are known to be rich. Coming east from these claims we find H. Q. and E. W. Roberts on the north side of the hill, and Frank Torpey & Co. on the south side. Both companies have done a large amount of work, and both have found good gravel. Still farther east, on the north side of the hill, are Webster & Co., the Picayune Company, Coombs, Grant & Co., and the Mammoth Company. On the south side are Hayes, Johnston & Co. These last-named parties adjoin the Hope Company's ground, and the ground of the Brown Brothers on Squirrel Creek. At the east end of the ridge we can see that the gravel is rich, for Brown Brothers and the Hope have already opened a splendid channel. On the west end of the ridge McSorley & Co. demonstrate that a good lead exists. Between the two points prospectors show that an old river-bed is in the ridge, and that the gravel thereof contains gold. Webster & Co.'s prospects are very good, and that state of affairs in their ground settles the matter of the value of the middle part of the hill. Extensive gravel mines are intended to be opened between Grass Valley and Rough and Ready. East Grass Valley is also an extensive deposit of gold-bearing gravel. The Town Talk mine, on the south bank of Wolf Creek, has proved a success, although it is scarcely touched. The lead is there of washed gold. The Independence ground, adjoining the Town Talk, is no less valuable. Buena Vista slide, and the hills by the slide, are shown to be rich in gold. Between Grass Valley and Nevada City, it will soon be demonstrated that the ridge has under it gravel which is more or less rich in gold. In this extensive gravel region prospectors are busy, and Grass Valley will undoubtedly soon be noted for its gravel mines, as it has been for years past for the successful working of quartz.

The new appliances and machinery introduced in this branch of mining during the year, and especially in Nevada county, are more fully discussed in another part of this report, and it is therefore unnecessary to repeat here what is already sufficiently treated elsewhere.

The quartz mines of the county have again been exceedingly prosperous, and, with the exception of the great fire at the Empire mine in September, which swept the company's milling and hoisting works out of existence, nothing has occurred to hinder steady prosperity.

Few gold quartz veins in the world have yielded the precious metal as regularly and abundantly, year by year, as the Eureka of Grass Valley. The claim includes now, since the Roannaise, an adjoining claim, has been acquired by the Eureka company, 3,700 feet on the lode. The works are located a short distance (hardly a mile) from the town of Grass Valley, and overlook the village, which is one of the most delightfully situated places in California. The veins at Grass Valley may be classed, according to their strike, into two systems—those running east and west, and those with a northwesterly and southeasterly strike. The Eureka belongs to the first class. It has, like all the veins of this system, a steep dip, the first 300 feet in depth, inclining 78° south, while the portion so far opened below this point varies from 65° to 70°. The main shaft is very large, 6 by 18 feet inside the timbers, and is divided into

four compartments—two for hoisting, one for sinking ahead, and one for pumping. The nine-inch pumps are built in three sections, the first reaching down to the second level, 260 feet; the second from here to the fourth level, 460 feet in depth, and the third to the sixth level, 255 feet lower. A sump of ten feet below this point is the deepest spot so far reached, making the total depth of the mine at the present time 725 feet on the incline. The thickness of the vein in the portions now accessible varies from 3 to 7 feet, and can be safely put down as 4 feet on an average. I should mention in this connection a peculiarity of this vein, which contributes largely towards cheapening and facilitating the work of extracting the ore. This is the distinct arrangement of two streaks of quartz—one along the foot-wall, and one on the hanging-wall—which are very frequently separated by a horse of from a few inches to 6 feet in thickness. This horse is interwoven with many small quartz-stringers, which are generally so rich in sulphurets that the whole horse must go through the stamps. On the hanging-wall is a distinct selvage, and by undermining ahead on the foot-wall, enormous masses of ore can be thrown down along the hanging-wall at a single blast. In a few localities both layers of quartz come together in the middle of the vein, without having the horse between. In these cases there is a line of quartz crystals visible, which fill the narrow cavity sometimes left. The whole vein shows very good evidence of the manner in which it has been formed. So-called "banded quartz" preponderates throughout the vein, and it is always found the richest in free gold and sulphurets. The vein is worked throughout by overhead stoping, shutes, 30 feet apart, being left open during the subsequent filling-in of the stopes throughout the mine.

The Eureka Company has always been noted for its good management of the mine, and has shown its business tact by keeping plenty of reserves ahead at any time. At present, for instance, the reserves in the mine furnish work for the force employed for the next three years; but they are nevertheless sinking slowly, and opening the mine farther in depth. The ores now raised come mainly from between the fourth and fifth levels, a few tons only being taken from the upper levels, where a good deal of twenty-dollar rock has been left standing in former times. The amount crushed per month during the last half-year has been 1,600 tons, which have yielded in the neighborhood of $56,000 per month, enabling the company to declare a regular monthly dividend of $30,000, and an extra dividend of $30,000 in July. Ninety-six men, at $3 per day, are employed in stoping, and one foreman for each shift at ten hours at $4 per day. Thirty men are employed for sinking and driving tunnels. They do contract work, and receive in the tunnels from $10 to $12 per foot.

The Eureka ore shows very little free gold, and little sulphurets. The latter, after concentration, are found to be about one and a quarter per cent. of the rock raised, and are further worked by the Plattner chlorination process. The company have their own works, but though they do custom-work besides their own, they can run the works only periodically, as it takes a long time to gather enough sulphurets to make a campaign. Nevertheless, five more chlorination establishments have been built in the county, all of which lie idle during the large portion of the year.

The Eureka mill is a large structure running a crusher and thirty stamps, which reduce 66 tons of ore per day. The amalgamation process in use is the well-known blanket process.

The annual report of the Eureka Company for the fiscal year ending

September 30, 1870, is one of great interest, and shows the situation of the Eureka in the completest manner. Mr. William Watt, superintendent, reports the working of the mill and mine for the year as follows:

We have driven 747 feet of drifts, and sunk 89 feet of winze, and 86 feet of main shaft. We have also retimbered 100 feet of the main shaft, run 22 feet of a cross-cut and cut cistern plat 12 by 12 by 12 feet below the bottom of the sixth level. The extreme length of the sixth-level drifts is 228 feet, and of the fifth-level drifts 1,167 feet, and we are still extending the same. We have hoisted 19,962 tons of quartz, and crushed 20,562 tons in 306¼ days, averaging a little over 67 tons per day with 30 stamps, losing three and a half days in consequence of scarcity of water, and three days for repairs, two of which were holidays. We have concentrated 203 tons of sulphurets, and worked 267 tons, leaving six tons on hand, which I value at $1,000. There are 1.198 tons of quartz on the surface, and 1,200 broke in the mine ready for hoisting. We have extracted this year from the various levels as follows:

Third level	1,290	tons.
Fourth level	4,727	"
Fifth level	13,945	"
Making a total of	19,962	"

Provided the resources of the fifth level are as good as those of the fourth, we may reasonably expect 27,000 tons of quartz more from the fifth level and above, or over one year's work for the mill. We have drawn nothing from the sixth level as yet, and therefore can safely say we have three years' work in sight for the mill at the present rate, without sinking. I regard the future of the Eureka mine as very promising, more especially as the sixth level shows a decided improvement over the fifth, and the ledge in the bottom of the shaft is looking well.

The Secretary's report contains the following recapitulation:

RECEIPTS:

By cash account, October 1, 1869	$54,871 49
By bullion account	661,893 47
By construction account	366 75
By sulphuret reduction works	6,571 70
By milling account	120 00
By premium and discount	3,001 00
Total	726,824 41

DISBURSEMENTS:

To dividends	$400,000 00
To mining account	171,404 59
To milling account	38,343 72
To sulphuret reduction works	7,921 70
To construction account	9,469 62
To wood account	3,510 25
To premium and discount	214 34
To Roannaise mine	205 50
To bullion expenses	2,505 68
To general expenses	8,890 42
To cash on hand, September 30, 1870	84,358 59
Total	726,824 41

The assets of the company, consisting of cash balance, sulphurets on hand, ore on hand, wood, supplies at the mine, mill and sulphuret works, mill and mine improvements, buildings, &c., are valued in cash at $194,497 70. There are no liabilities. The mine has been in operation, under its present management, since October 1, 1865. In the five years the bullion taken out amounted to $2,805,282 77, and from other sources came the sum of $17,283 81, or a total of $2,822,566 58. In the five years the dividends amounted to $1,334,000. The disbursements for the five years (including dividends) amount to $2,721,020 24. The ore (including sulphurets) paid, for the year just past, $31 75 per ton against $27 80 per ton for the year before. The company have paid fifty-three consecutive dividends in fifty-one months. The cost of mining ore at the

Eureka for the year past has been $8 32 per ton. The cost of milling the same has been $1 84 per ton. The cost of concentrating the sulphurets has been $18 24, and the cost of reducing the samé $15 25 per ton.

The bullion receipts of the Eureka Company for the calendar year 1870 are given by Mr. Richard Wheeler, of the San Francisco Stock Report, as $683,328.

The Idaho is located on the eastern extension of the Eureka lode. The vein presents the same characteristics as the Eureka, but it appears that in the upper levels the quartz extends only about 300 feet east of the latter, where it pinches out. In the lower levels the quartz extends farther, so that the line of termination would be on a flat incline from west to east. The shaft of this company is located a little over 200 feet from the Eureka line. The ore is taken out clean from the upper levels, and has yielded very fine returns. For the last six months, however, I am informed the mine has paid no dividends, though it pays expenses. They are now opening up the mine in depth, and take their ore at present from the fifth level. The mine having been in operation only a few years, the shortness of their vein has compelled them to advance rapidly in depth; but in this direction lies also their main hope for the future, as their field of operations extends continually in length. The following extract from the report of its officers to the company shows the condition of the mine, and details all the work which has been done for the year:

There have been 88 feet of shaft sunk, 449 feet of drifts run, and 330 feet of winze raised. The six-hundred-foot level is now being opened, while the shaft is being sunk for the seven-hundred-foot level. The shaft is now down 41 feet below the six-hundred-foot level. From the sixth level (600 feet down) the drift running west is in 112 feet from the shaft, and the drift east, on the same level, is in 117 feet from the shaft. From the fifth level, 1,320 tons of quartz have been taken, and that level is now being worked. The fourth level, 400 feet down, and all the levels above it, have been exhausted. During the year, three steam-pumps, known as the Stoddard pumps, have been put into the mine, and the Cornish pump has been taken out. This gives room for more hoisting-way in the shaft, as the compartment heretofore used for the Cornish pump to work in is now used as a hoist-way. The Stoddard pumps do all the work required at the Idaho, and the three are run at about the same expense as was required to drain the mine with the Cornish pump. The Stoddard pump has been used since July last, and has proved entirely satisfactory to the Idaho Company. The water in the Idaho mine, however, is easily handled. The company have put in during the year a new ten-inch cylinder hoisting engine and a new boiler. They have also repaired and retimbered 303 feet of shaft. The mill, which is a 15-stamp one, has been kept constantly running during the year. The crushing for the year is 9,782 tons of quartz, which gave a gross yield of $187,034 10, or an average of $19 03 per ton. The labor account of the mill and mine amounts to $85,523 61. This includes all the labor performed on the surface and under ground. The other expenses of the mill and mine amount to $30,384 04, or a total for expenses of $115,007 65. The cost of the quartz, therefore, in milling and mining amounts to $11 85 per ton, or a profit of $7 15 per ton on the rock crushed. During the year, the repairing and construction expenses have been $12,699 75. The sulphurets saved have cost the company the sum of $3,339 12 in saving and working the same, and these sulphurets yield the sum of $8,669 04, giving a profit of $5,329 95 on sulphurets. The receipts from all sources by the Idaho Company for the year amount to $69,962 57. The dividends declared amount to $12 to the share, and amount in the aggregate to the sum of $37,200. The cash on hand is $11,358. The company have paid out during the year, for attorney's fees and patent to the ledge, the sum of $2,442 50. The Stoddard pump cost the Idaho Company $2,500. The number of men employed at the mill and mine is 101, and of these all receive $3 per day, excepting twelve men, who get $2 50 per day as wages.

The Empire mine and the reduction works were unfortunately stopped, and the latter entirely destroyed by fire—mill, hoisting and pumping works, about 2,500 cords of wood, and $6,000 worth of winter supplies, candles, powder, &c.—on the 20th of September, 1870.

In regard to the developments in the mine of late, a correspondent at Grass Valley writes me:

The property changed hands, and Mr. Nesmith took charge April 16; since then he had opened it up and discovered an under ledge, lying from a few inches to 20 feet back

of the old workings, from the tenth level up to the seventh, and from all appearances it will extend up as far as the fourth. It is extra rock, in tenth, ninth, eighth, and seventh levels, where he has found it good, from $35 to $40 per ton. He has also made many changes in working, and was mining to an extent of 600 tons per month, with sixty hands in all, and as soon as rains came, would have mined and worked 1,000 tons per month, with not over eighty-four men. This, with a ledge from 12 to 24 inches is, you will allow, good work. The new mill will consume one and a half cords wood less per day, and require two men less, so the old cost of reduction ($2) will be materially reduced. For the month of August it cost $12 25 to mine and reduce the rock. As Mr. Nesmith's safe proved to be a broken reed, and destroyed all books and papers, he will have a clean start.

Early in 1871 the new mill was completed and running, and Mr. Nesmith, the company's superintendent, writes to me:

The new mill is running steady, and is a decided success. With a crew of ten men I run the mill night and day, reducing about 40 tons of quartz per day and working all sulphurets and concentrations. Mr. A. J. Rigby, the contractor, has given us a splendid job in every particular, and the new pans (the Booth & Co. combination of Wheeler, Hepburn & Varney) are all that could be wished. This is gratifying, for the grandfathers of the Grass Valley miners did not use pans, and if the next generation did try one it was an Arrastra or Chili mill, consequently any fast-grinding pan was bound to be a failure. A short time will put the Empire in a condition for us to forget there ever was a fire. Three months from the start the hoisting and pumping works were built, mine pumped out and mill built and running, and it is generally conceded to be the best work in Nevada County.

An English company have bought the East Eureka (old O'Connor mine) and are about to build a 20-stamp mill upon it, already under contract.

The South Star, on Dead Man's Flat, has been put in order, good serviceable machinery erected, and the mine started, with promise of a fine mine. The old Osborn Hill mine is running under a lease, and yielding $48-rock, which pays all parties well. The Defiance, in the same locality, is erecting hoisting and pumping works, and hopes to be running in March.

The new hoisting engine of the Empire has a 12-inch cylinder. The new pump, 13-inch, put in the mine in place of the 10-inch pump heretofore used, is very effective. There are over one thousand cords of wood on the ground at the Empire, and teams are constantly engaged in adding to the pile. The new crushing-mill is one of twenty stamps, but these will be capable of doing the work of the thirty stamps destroyed by fire.

In November the Grass Valley Union gave the following account in regard to the mines of the neighborhood:

Perrin's mine has been doing well, though it is not quite up to its old mark. The ledge is large, however, and sixteen men can keep the mill running. Last week the sixteen men took out 40 ounces, and the week before they took out 43 ounces. As the cost of milling is small (water-power being used) the profit of this yield is good. Dromedary, located in this town, is being worked under a lease, by a company of practical miners. Lessees have contracted to have a 5-stamp mill put up at the hoisting works. This mill will be run by the hoisting engine, which can furnish plenty of power for the purpose. The rock coming from the Dromedary is looking well in sulphurets, with occasional gleams of free gold.

The Phœnix, at Vail's Ranch, is turning out some splendid rock. There are two Phœnix ledges in the district, which are showing well. The one we now speak of is owned by Pat Hennessey, of Allison Ranch. A shaft is going down which will strike the ledge at the depth of 35 feet. The rock on the croppings has paid $20 per ton, so far, and at the lowest depth the rock was best. The ledge is now of such size that four men can mine and hoist by windlass four tons per day. These miners take out this rock and land it on the surface for $3 50 per ton. This leaves $16 50 per ton for hauling and crushing expense. The profits to the owner, it will be observed, are handsome.

The Wild Emigrant is located on Wolf Creek, about ten miles south of Grass Valley, near the lime-kiln. In that vicinity little or no mining has been done. The residents there have been raising grass for hay, and scratching around occasionally for a gravel claim when water was plenty. The Wild Emigrant ledge is looking well, as far as worked. It grows better as it goes down, and widening at the same time. The rock taken out is good for $40 a ton, and the dirt around the ledge is very rich in gold. The country rock about the Wild Emigrant is slate, in which the valuable permanent ledges are almost always found. At the lowest workings the ledge is two feet thick, and, as we said before, is widening. The Phœnix, of Sebastopol Hill, is being worked with

great success. A number of tons from this mine is on the platform at Ben McCauley's mill, Boston ravine, and the rock will give something like $40 per ton, according to past yields from the ledge taken with the present appearance of the rock. The North Star has been running full-handed at the mine for the month, with good results. Last Friday we saw some very rich rock which had just been hoisted, the beautiful heavy gold running through and through the pieces. The North Star is a paying mine. The Idaho, situated next adjoining the Eureka to the east, has shown some improvement in the month past. In the lower levels this improvement was very manifest. The Wisconsin has not finished its month as yet. The run will come up to about the average of this steady-paying mine. The three weeks' run, which has been completed, indicates a less yield than a corresponding yield of last month, but the rock now being put through is of such a character as will bring the month's run up to the regular standard, say $5,000 for five stamps in one month. The Greenhorn mine, on the creek of the same name, is doing well. The new hoisting and pumping works, operated by steam, prove an entire satisfaction. Water is yet wanted for the purpose of starting up the crushing-mill. As soon as the rain comes the mill will commence to run with plenty of good rock on hand, to last till the next dry season.

The O'Connor or Grass Valley Consolidated mine, situated to the east of the Eureka and Idaho mines, is sending good rock to the surface. It is said, and we hope the saying is true, that there is a probability that the O'Connor will be worked in a regular and systematic manner. The past of this mine should insure its development. The Pennsylvania mine, on Kate Hays's Hill, extending into Mary's ravine, has kept the Gold Hill mill running for several days, on very good rock. This mine must not be confounded with one of the same name at Nevada City. A week or two since the Pennsylvania or Grass Valley was in a lawsuit, which stopped all work. The suit being settled, good ore is coming out. There are two Franklin mines in the district. One is just north of the Allison ranch mine, and is supposed to be on the same ledge. The other is on the Coleman road to Colfax. Both of these mines are being worked in what appears to be paying rock. Ben McCauley's mill has some eight or ten piles of custom-rock on its platform. These piles are from as many parts of the district. The Ryan ledge, located east of Grass Valley and northeast of the Eureka mine, is still looking well. The owners expect some good from a crushing which is soon to take place. The South Star is a mine upon which machinery is being placed. It is owned by Messrs. Hoyt & Co., and is located near the North Star. The Manhattan, nearer to Nevada City than to Grass Valley, but in the slate formation of Grass Valley, is showing well. The ledge is two feet thick, and shows plentifully in free gold as well as sulphurets. We saw a prospect on Sunday from a pan of dirt taken out next to the ledge, which gave, as we judged, over one dollar's worth of gold. The Orleans, near Mallman's sulphuret-works, on the Nevada road, is showing rich quartz. The shaft is down about 75 feet. From the bottom comes rock through which gold is plainly visible to the naked eye. The gravel mines all over the country are preparing to be worked more industriously this winter than ever before. Omega will be a very lively place as soon as the waters come. Omega is in the north of the county, and Rough and Ready, which is in the southwest of the county, expects to do as well. In Rough and Ready McSorley & Co. will be prepared for extensive hydraulic works by the time water is plentiful. Webster & Co. have their diggings well prepared for profitable washing when the pluvial shall fall. Hayes & Co. have their flumes and pipes ready for moisture, whenever moisture shall amount to a pressure. Other companies on the same ridge are making arrangements to soon commence work. The Alta Company, No. 3, have steam-works ready for hoisting and pumping. The ground of this company is located northeast of the Hope. The Hope company is running in rich gravel, with more than paying results. Gravel claims east of this are being extensively worked. Shea & Co., at Buena Vista, the Town Talk, awaiting water, and Underwood & Co. are ready to make a good winter's run. At Nevada City gravel mining is still more active. On Cement Hill, three miles west of Nevada, a company has put up flumes of sixty boxes, 12 feet to the box. These boxes are 4 feet wide. These diggings will be worked by hydraulic process, and the working will require 500 inches of water, miners' measure, each day, for their working. On the 1st of December it is expected the water will be turned on. The claims are divided into four shares on the cement claims. A patent is to be applied for very soon. The Butts & Co., who have prospected for quartz in the bed of Wolf Creek, just above the Idaho mine, have obtained very good rock. That ledge should be followed, since in that part of the country mining has paid. A more active and profitable state of prospecting has never been known in Grass Valley. The custom-mills are kept at work, and this by men who make money by the work of the mills.

The North Star has been worked steadily, and declared three dividends during the year. The result attained so far is gratifying, as will appear from the following extract from the company's annual statement published in October:

RECEIPTS:	
Bullion	$151,598 58
Skimmings, sulphurets, &c	24,577 25
	176,175 83
Liabilities	4,067 25
	180,243 00
DISBURSEMENTS:	
Mining labor	$66,197 67
Milling labor	17,749 37
Dead work	10,387 17
Mill supplies	25,853 02
Mine supplies	14,751 02
Liquidated debts	14,780 98
Dividends	6,000 00
Salaries, &c	5,295 25
Sundry accounts	17,839 27
Cash on hand	1,389 33
Total	180,243 08

They produced 7,834 tons of ore, which yielded at the rate of about $21 37 per ton, or $167,431 in the aggregate. The expenses of mining, milling, &c., amounted to $16 73 per ton, leaving a profit of $4 64. Of this profit $6,000 has been paid to stockholders, $14,781 on account of obligations incurred in the previous year, $10,387 for dead work, and $7,741 for improvements. The supplies on hand on September 6th are estimated at $18,295.

The product of the same mine in the following months was satisfactory, the October yield having been $18,000, and at last accounts the North Star appears to be in a good way to be added to the steady dividend paying mines of the district.

Besides the mines already named, many others were in successful operation during the year, and it is not too much to say that the last was the most prosperous year for the quartz mines in Nevada County.

The census returns for the year ending June 1, 1870, give the following details in regard to the mines:

Product for the year ending June 1, 1870.

Goodspeed & Co., Little York, cement	$21,350
Nace & West, cement	20,000
Gold Hill Mill, Grass Valley, quartz	7,000
Sebastapol Mill, quartz	9,600
Orleans Quartz Mill, quartz	4,000
Town Talk Company, quartz	18,500
Slate Creek Company, quartz	38,731
Union Hill Company, quartz	140,000
Empire Company, quartz	240,000
Greenhorn Quartz Mill Company, quartz	15,000
Eureka Company, quartz	601,944
Idaho Company, quartz	223,871
Prospect Company, Eureka, quartz	552
Oriental, Nevada, quartz	3,000
Pittsburg Company, quartz	150,000
Star Spangled Banner Mill, quartz	135,180
Total	1,628,728

All the sulphuret works (five) were in operation for only a short time, and their total product, leaving out that of the Eureka works, amounted to only $52,000.

From mining and prospecting operations other than those already mentioned, a yield of $132,000 in the aggregate is reported for the year ending June 1, 1870.

An article from the Grass Valley Union in regard to a new concentrating machine invented by Mr. Stephens, and called the Rawlins & Stephens slime ore-concentrator, is deemed worthy of reproduction in this place. A good machine of this kind is a great desideratum, the apparatus so far employed having generally been cumbrous and costly, and not as effective as is desirable.

This concentrating machine is cheap in construction, can be run with very little power, and requires very little attention. All the mining and mill men who have seen the concentrator work pronounce it the best machine yet constructed. One has been used at the Wisconsin mill, near Grass Valley, for several months, and has given the most entire satisfaction. We yesterday saw a large machine at work, below the Banner mine, near Nevada City. The concentrator at the latter mine is a wheel 20 feet in diameter, with distributing table of 12 feet. The traveling table is 4 feet wide. This is working on sand which has gone through several concentrating processes. It is at work below two Paine & Stephens buddles, four rockers, and 300 feet of sluices. After all these have taken sulphurets from the sand which they can save, the sand is run on a Rawlins & Stephens machine. Of course the sulphurets in such sand are light, with only a small percentage of the heavy article which escapes from such complete working. The result is that the Rawlins & Stephens concentrator saves about four or five tons of sulphurets per month, at the Banner mine, from sand which was supposed heretofore to be completely worked. The sulphurets thus saved are worth $60 per ton gross at the chlorination works. The expense of running the machine is $2 50 per day, or $60 per month. This expense can be further reduced, as a smart boy can attend the machine. We have then in these figures a "proof of the pudding," in the case of the machine at the Banner mine. From four tons of sulphurets saved at $60 per ton, giving $240, deduct $60 for labor and $80 for working the sulphurets by chlorination, total expense $140. This gives $100 per month profit on a machine which cost, in the first place, say $500. It has been demonstrated that no machine now known can go below the Rawlins & Stephens machine and make anything. Where the Rawlins & Stephens concentrator works just as the tailings come from the mill, as in the case at the Wisconsin mill, it saves almost all the sulphurets, light as well as heavy. It allows but very little metal-bearing slime to escape. We have the opinion of many experienced quartz miners for saying that the Rawlins & Stephens concentrator is the best machine or buddle in use. At the Banner mine, before the new machine was put up, at the sand pile where it is now used, a company had a percussion table, 4 feet wide and 18 feet long, two revolving cylinders, one to grind the sand and the other to amalgamate. The arrangement was run by a 20-foot water-wheel. The company using these implements lost about $1,500. Stephens is thus making money where others have lost.

The population of Nevada County, as per census of 1870, is: Total, 19,134; Chinese, 2,629.

SIERRA COUNTY.

The placer and hydraulic claims, though much injured by the drought, have again yielded handsomely, and the former especially have given very satisfactory returns. There are nine claims of this class reported in operation an average of ten months. They furnished employment for 169 men, whose wages varied from $2 50 to $3, a considerable decline from last year's rates. The total yield of these placers for the year ending June 1 was $225,000, and the yield per hand per day in the neighborhood of $4. The total amount paid for water was $5,580, and for timber $10,800. Nearly all the claims were operated on a large scale, by companies, and the following were the most productive: Nevada Company, (Table Rock,) $26,030; Redding Company, $13,500; North American Company, $50,450; Hawk Eye, $65,000; Monumental Company, $31,590; Fashion Company, $29,000.

The "dead river" system of this county was fully described in my last report. The hydraulic mines have especially suffered from want of

water during part of the year. There are ten claims reported in operation during nine months on an average. They employed 151 men, who were paid about $65 per month to the hand. The total yield was a little less than $150,000 for the year ending June 1, 1870, making an average of $4 70 per hand per day. This is proportionately less, as far as profits are concerned, than the yield of the placer mines. The price paid for water ranged between 5 and 10 cents per inch, according to the locality. The largest returns are those of the Union Company, which amounted to $98,000, and those of the Goab Company, which were $12,000.

Quartz-mining operations have been, on the whole, satisfactory. An important change of proprietorship ought to be noticed in this connection, as showing the tendency of foreign capital to invest large amounts of money in mining property already developed and paying dividends, rather than in new enterprises. I refer to the sale of the celebrated Sierra Buttes mine to an English company, which was concluded in the course of the summer.

The total amount of quartz raised in the county during the year ending June 1, 1870, was 40,600 tons, which yielded $438,000. One hundred and ninety-three men were employed in the mines and mills throughout the year, and $135,244 was paid to them in wages. The following are the most prominent mines and their yield for the time indicated above: Alaska, $30,000; Gold Bluff, $37,322; Independence, $75,000; Sierra Buttes, $200,000; Brush Creek, $95,000.

The population of the county, according to the late census, is: Total, 5,619; Chinese, 809.

YUBA COUNTY.

Hydraulic mines appear to have been quite successful during the year. The details in regard to the situation, &c., of the most important of these mines are contained in my last year's report and in the excellent article of Mr. Skidmore, at the end of this chapter. I note here briefly only some points of interest from the returns of the census.

The number of claims reported in operation during the year ending June 1, 1870, is 47. These employed 308 men, who were paid $60 per month to the hand. The total product from June 1, 1869, to June 1, 1870, was $461,900, being $5 84 per hand per day.

The following claims yielded the highest amounts: Pittsburg and Yuba Mining Company, employing 25 men 12 months, $75,000; Blue Gravel Gold Mining Company, employing 40 men 12 months, $66,070; Antone Mining Company, employing 6 men 9 months, $13,050; Union Mining Company, employing 7 men 12 months, $17,868; Rosebar Mining Company, employing 43 men 12 months, $85,910; Smartville Mining Company, employing 40 men 12 months, $103,000; Nevada Mining Company, employing 35 men 9 months, $23,760.

Placer-mining was not carried on to any considerable extent. Only five claims are reported, which employed 22 men during 6.3 months on an average. The total product of these claims was $11,400, which indicates a yield of $3 14 per day per hand.

The largest yield of any claim is only $5,000, and the remainder produced less than $3,000 each.

The exhibit of the quartz mines is still less encouraging. According to the reports received, only two mines were working, which during the year ending June 1, 1870, employed a few men for a short time. These are the Hansonville Company, which employed from one to three men underground during six months, and raised 238 tons of quartz, worth

$16 97 per ton on an average, or $4,040, and the Pennsylvania Company, which worked during four months, employing at different times from six to twenty men underground, and took out $6,640. This would make the total product from the quartz mines of this county $10,680.

The population of the county, as per census of 1870, is: Total, 10,851; Chinese, 2,333.

BUTTE COUNTY.

The placers and hydraulic mines have suffered from the want of water, and the quartz mines have not overcome the obstacles existing against profitable development which were alluded to last year.

The difficulty in regard to the gravel mines of Cherokee Flat, a locality known to be rich for a long time, but which could not be worked to a great extent, because a large investment was required to bring water to the place, seems to have found a happy solution. A company concluded to bring water to the mines from Concow Valley, and at latest accounts the undertaking has been a success. The *Scientific Press* has published an exhaustive article in regard to this enterprise, which I quote here:

The history of hydraulic mining in California has been one of bold engineering feats. We have to-day to speak of a new enterprise, the boldest of the kind yet attempted, which has lately been successfully brought to completion, and has opened a new field for the hydraulic miner. This is the introduction of water to the Cherokee gravel mines in Butte County.

This region has been worked to some extent for many years, but only during the winter months, with such water as could be obtained from reservoirs in the rainy season. From its elevation, however, there was but little opportunity for collecting water, and hence the locality, although known to be rich, has received but comparatively little attention. We propose to give a short description of the manner in which water has been carried into this place, and of the difficulties encountered and overcome.

The success of the sheet-iron pipe used by the Spring Water Company of San Francisco, led to the employment of one of greater magnitude, in the locality first spoken of, and induced Messrs. Judson, Abby, Davis, and Doe to undertake to convey water to the Cherokee mines. A ditch had been constructed from Concow Creek to Yankee Hill, and from this place the water had to be carried across the ravine of the West Branch to the opposite mountain, whence it was conducted in a canal to the mines of Cherokee Flat.

The inlet to the pipe is 150 feet above the outlet, with a vertical height from the lowest point to grade line of 900 feet. The pipe is 30 inches in diameter, and is intended to carry 1,900 miners' inches of water. The thickness of iron used is No. 14 for 150 feet of pressure, No. 12 for 275 feet, No. 10 for 350 feet, No. 7 for 425 feet, $\frac{1}{4}$ for 600 feet, $\frac{5}{16}$ for 850 feet, and $\frac{3}{8}$ for 900 feet. The water is admitted at the upper end from a cistern, with sand box, &c., for settling any sand or gravel brought in from the ditch. The pipe has here an elbow dipping into the water to prevent the entrance of any air. Fifty feet from the inlet there is a stand-pipe to allow the escape of any air which may have got into the pipe, and to guard against an overhead of water. At different places, especially where depressions occur, are placed air-valves, made with floats, to allow the escape of air, which shut on the approach of water. If the water is drawn off, these open on the inside, preventing the collapsing of the pipe from atmospheric pressure.

The pipe was laid in a trench, (5 feet deep,) from one end to the other, and covered with earth to prevent any undue expansion and contraction in hot and in cold weather. It does not extend quite to the bottom of the ravine, but is carried over on a truss bridge at a height of about 70 feet. It was laid in lengths of 23 feet, which were riveted one to the other continuously, man-holes being placed every 1,000 feet to allow the entrance of the workmen. The rivets used were, for No. 14 iron, $\frac{1}{4}$ wire; No. 12, $\frac{1}{4}$; No. 11, $\frac{5}{16}$; No. 9, $\frac{3}{8}$; and No. 7, $\frac{3}{8}$; driven cold. The first ($\frac{1}{4}$) was machine-riveted cold, hand-riveted hot; $\frac{5}{16}$, $\frac{3}{8}$; $\frac{3}{8}$; $\frac{1}{4}$ driven hot. A steam riveting-machine was employed for nearly all of the pipe, giving better results than the hand labor.

The pipe was made at the rate of 1,100 feet per day, giving employment to a large number of men. The punching and shearing was done by machinery expressly designed for this pipe, and as high as 30 tons of iron were worked daily, 87,000 feet of pipe being manufactured and laid in place, and the water run through, in four months from the commencement of the enterprise.

The thickness of iron required here gives us a datum for computing the comparative cost of cast-iron and of wrought-iron pipe; ⅜ wrought-iron sustains here a pressure of 385 pounds to the square inch, for which 3-inch cast-iron (nearly) would be required to make it safe. The freight alone of such a cast-iron pipe would render the enterprise impracticable.

Such is a brief outline of one of the greatest undertakings of the kind ever attempted, and one which opens a new and rich mineral region. That a work of such magnitude and boldness should be conceived and carried out, redounds greatly to the honor of our Pacific coast. It speaks most highly for the talent of the engineers who conceived the plan, the enterprise of the men who undertook to put it in execution, and the ability of the mechanics who made it an accomplished fact.

There were only four placer claims reported in operation in June, employing 25 men on an average of 8.4 months. White labor cost $55 per month, and Chinese $28 on an average. The price of water was 5 cents per inch. The total yield was $30,200 for the year ending June 1, 1870, or $5 50 per hand per day. The most prominent claims are those of Kennedy & Co., which employed six men throughout the year and yielded $16,000, and of a Chinese company, which employed 15 men for six months, and yielded $9,000. Thirteen hydraulic mines, in operation 8.45 months on an average, employed 119 men. The total yield of these was $169,000, or $6 47 per hand per day. The following are the most prominent: Cherokee, $75,000; Monte de Ora, $10,000; Oroville Company, $30,000; Moore & Company, $12,000.

Only four quartz mines were worked during eight months on an average, and the total product for the time above named was only $22,512. The number of miners employed was 31, and $65 were paid per month to the hand. The mines are all, as yet, unimportant affairs, the one of A. W. Halstead yielding the highest product, $10,000.

The population of the county, according to the census of 1870, is: Total, 11,403; Chinese, 2,082.

PLUMAS COUNTY.

The quartz mines of the county have again yielded quite handsomely. The product from the placer and hydraulic mines is not so satisfactory.

Of the placer claims, 44 are reported working during an average of six months. They employed 269 men, at average wages of about $70 per month. The total yield of these from June 1, 1869, to the same time in 1870, was $177,500, or an average of $4 22 per day per hand. The following claims are the most prominent: Alturas Mining Company, Goodwin, employing forty men for five months, $14,000; Conly & Gowel, Goodwin, employing thirty men for four months, $20,000; Gaid & Orr, Goodwin, employing thirty men for three months, $15,000; Buckeye Mining Company, Washington, employing seventeen men for twelve months, $34,000; New York Mining Company, Washington, employing sixteen men for ten months, $29,000; Eagle Mining Company, Washington, employing twelve men for twelve months, $6,000; Kelley & Company, employing four men for eight months, $6,800.

From Goodwin, Mineral, Rich Bar, Plumas, Washington, and Indian Valley, (Cherokee district,) 31 hydraulic claims are reported, which employed 108 men during 5.1 months, and at $65 wages on an average. The claims are largely worked by the owners themselves, and wages have not been paid in many cases. The total production during the above-mentioned time has been $67,300, which shows an average yield per hand per day of $4 66. The highest amounts taken out were, $15,000 by the Lecup Diggings Mining Company, who employed ten men six months, and $6,000 by Turner, Rice & Co., who worked four men seven months.

The four principal quartz-mining enterprises in actual operation were the following:

Eureka, employing seventy men for eight months; product, 8,000 tons, worth	$80,000
Judkins & Kellog, employing thirty-two men for eleven months; product, 8,000 tons, worth	60,000
J. B. Batchelder, employing six men for eleven months	9,114
Crescent Company, employing fifty men for twelve months; product, 15,000 tons, worth	120,000
Total	296,114

The wages paid by these companies amounted to $136,400, and the necessary materials to $37,849.

Besides these, a few smaller mining enterprises have been in operation part of the time, but the yield is not such as to make any material difference in the total already given. New discoveries, some of which are reported to be very rich, have been made in American and Indian Valleys. In the former a new thirty-two stamp, and in the latter a twenty-four stamp mill, are said to be in the course of erection.

The population of this county, according to the census of 1870, is: Total, 4,489; Chinese, 911.

ALPINE COUNTY.

The following account was kindly written, at my request, by Mr. Lewis Chalmers, manager of the Exchequer Gold and Silver Mining Company:

Mining operations in this county during the past year have been carried on to a greater extent than for some time previously.

The Leviathan, a copper mine about two miles from Monitor, has shipped considerable quantities of a high grade ore to Dayton, where, I understand, it is used in the manufacture of bluestone. This mine belongs to an English company, and is under the management of Mr. Rickard, some time of the firm of Wiegand & Rickard, in Virginia City. Native copper is frequently met with, and the best ore gives 50 per cent.

The Schenectady Gold and Silver Mining Company, owning the Tarshish mine, in Monitor, resumed operations there about two years ago, under the managership of Mr. Schwerin, who is also a large owner. Very fine black sulphuret ore has been struck lately in large bonanzas, which, when washed, will pay as high as $2,000 per ton. Several tons have been shipped to San Francisco for sale as ore. The manager has gone to Schenectady to make arrangements for the erection of a mill this summer. As usual, much excitement followed the new discoveries, and real estate in Monitor commands a premium.

The Monitor and Northwestern, on the Tarshish ledge, have lately struck outlying pockets of the same description of ore, and are now adding a 50-ton Whelpley & Stover furnace to their mill on the Carson River, about a mile from this place. Mr. L. L. Lewis is superintendent.

The Globe company, in Monitor, have almost completed their mill, which is on a somewhat new principle. This company owns the Globe mine, on Monitor Creek, claimed to be on the same belt as the last two, but on the opposite side of the creek. They are now experimenting on Chicago and Globe ores, but with what success I have not heard. They appear to think that they will be able to reduce rebellious ores at a *lower* rate than by any other process yet known. Contracts have been

entered into for the purchase of the Chicago and Marion mines, in the vicinity. The Marion has a great reputation, very rich specimens of black sulphuret having been taken from it. Mr. Ambler is the metallurgist and superintendent, and Colonel Winchester, of New York, the managing director.

The Bullion Gold and Silver Mining Company have been driving a bedrock tunnel from the Carson River, at Bullima, to cut a belt of parallel ledges at right angles to their tunnel, which is now in over 1,700 feet. This is an English company, managed by Mr. Coulter, and has been hard at work for three years. Mr. C. is expecting daily to strike one of the series. They have had some very hard rocks to contend with, but are determined to push it through. The Highland Mary seems the favorite ledge of the group.

The Imperial Gold and Silver Mining Company, also an English incorporation, have run a tunnel 1,400 feet into Mount America, to cut the belt of parallel ledges (some 17) on the east side of Monitor Creek. The indications on the surface are very encouraging. The outcrops assay well, and are traceable for quite a distance; 300 feet will cut the first lode.

The Exchequer Gold and Silver Mining Company, of London, England, are operating on the old Buckeye No. 2 and other ledges, at the head of the Scandinavian Cañon, near Silver Mountain, the county seat of Alpine. The ledges here are well defined and give great promise. In this respect, nothing better could be wished than is to be seen in the upper tunnel on the Buckeye ledge. This company commenced in February, 1870, and in March following shipped to Reno a few tons of unassorted ore by way of experiment, which yielded, at the Auburn mill, $140 per ton, and produced bullion 901 fine. At that establishment, the roasting is done in the Stetefeldt furnace. The work since then has been confined to the development of the mine. Stoping will be commenced from the 140 level in the spring, when I hope to be able to keep the Davidson mill, on Silver Creek, now the property of the Exchequer Company, in full blast for some time. Our ores are chiefly antimonial sulphides, miargyrite, dark red silver ore, and light red silver ore. We have also the lead-gray sulphuret, or silver glance. Lead is to be found in some of the ore in small quantity. Selected specimens of the best ore assay as high as $2,000 per ton, and all the ore contains more or less gold.

The mill has eight stamps. Weight, 600 pounds; drop, 60 per minute; six Freiberg barrels, and one settler, all driven by a 40 horse-power engine; two reverberatories and one drying furnace. Should the mines turn out as expected, it is contemplated to increase the stamps and add a 30-ton Stetefeldt furnace, to cheapen the roasting, which is expensive in the common reverberatory. A saw-mill attached supplies the mine with timber, the teams returning with ore. The slabs supply the furnaces.

The once famous I X L adjoins the Exchequer Company's mine south, but work here has been suspended for some time. I have seen some beautiful specimens of ruby silver, and one of native silver, from this mine. Some forty or fifty thousand dollars are said to have been taken from the workings on this ledge, which are only superficial. A moderate outlay for hoisting works, and a depth of 200 feet would, I think, amply repay the cost. The last batch of ore was treated at the Pittsburg mill, Silver Mountain, without roasting, and one half of it lost. I got $50 in the tailings.

The Pennsylvania, Mountain, Rippon, and Pittsburg, all in the same

district, (Silver Mountain,) are also shut down for the present, though rumor has it that the I X L, Pennsylvania, and Mountain will soon be at work again under different auspices, and, it is to be hoped, more energetic management.

There is no quartz in this section equal to that of Silver Mountain. Wood and water are abundant, labor is plentiful, and there is, I think, every prospect of a speedy resuscitation of this temporarily deserted mining camp.

Some little work was done in the Morning Star mine, Mogul District, but of no consequence.

SHASTA COUNTY.

The product of mines, placer and hydraulic, as well as quartz, has been less this year than last.

The placer claims reported working have all yielded small amounts. The most prominent returns are those from the claim of J. H. Harrison, who took out $12,000 in nine months. Besides this enterprise twenty others are reported, all of which produced less than $1,000 each, and the total of the county is only $31,600 for the year ending June 1, 1870. Only forty-eight men were employed in this branch of mining during an average of six months at wages of about $60 per month. The yield per head per day was $4 20.

Only four hydraulic claims were in operation part of the time, the total yield of which was a little over $12,400. The most prominent of these took out $10,000 in eight months with seven men.

The quartz mines especially have fallen off in their yield.

The following three mines and mills were being worked, and produced altogether $44,640: Washington, $31,153; W. E. Hopping, (Highland mill?) $9,650; Honeycomb, $3,836.

The total amount of quartz raised was 2,500 tons, which yielded an average of $17 87 per ton, and the number of men employed was thirty-three. Average wages of $76 per month were paid.

The population of this county, according to the late census, is: Total, 4,173; Chinamen, 574.

TRINITY COUNTY.

From this county only placer and hydraulic claims are reported. Of the former, eighteen claims employed eighty-four men on an average of 8.4 months, at about $55 per month. Among those reported working are many owners. The total product of these mines for the year ending June 1, 1870, was $92,500, and the average yield per hand per day, $5.

The following claims yielded prominently: Fisher & Chapman, Junction City, employ eight men eight months, $10,000; Carson & Osgood, Minerville, employ ten men twelve months, $12,000; Harney Bros., Minerville, employ seven men eleven months, $10,000; Kerl & Co., Minerville, employ six men six months, $7,000; Hupp & Co., Minerville, employ six men eight months, $8,000; Hawkins & Co., Minerville, employ ten men eight (?) months, $8,500; H. Foible, North Fork, employ four men ten months, $6,000.

The hydraulic mines of the county do not appear to have been very successful, nor are any of the eighteen claims reported large enterprises, the highest capital invested not exceeding $10,000, and the highest yield being $6,700. The different mines are located at Junction City, North Fork, and Lewiston. Fifty-five men were employed during 7.6

months, and at $60 per month on an average. The total product is reported as $60,700, a yield per hand per day of $5 57.

The price of water in this county is reported as ranging from 1.3 to 5 cents per inch, but most of the claims pay from 2.9 to 3.5 cents.

The population of this county is: Total, 3,213; Chinese, 1,095.

KLAMATH, DEL NORTE, SISKIYOU, AND LASSEN COUNTIES.

The product from these counties is small. From the first two placer claims are reported, yielding together less than $8,000. The Pioneer Company employed six men during the year, and paid $4,000 in wages; the yield was 200 ounces of gold, worth $3,400. The Union Company employed the same number of men in the same time, paid $5,500 in wages, and produced 240 ounces, worth $4,500.

The only quartz-mining enterprise reported is that of the Klamath Quartz Mining Company. This company employed twenty-five men during ten months, at a cost of $24,000. The product was 2,500 ounces of gold, worth $42,500.

From Del Norte County only placer and hydraulic mines are reported, the former including some beach-mining. The placers are located at Smith River, Happy Camp, and Crescent City. Nine claims are reported, most of which worked throughout the year; the one, however, which returned the highest yield was worked only six months, with six hands, and produced $10,000. The total product of all the placer claims was $21,100 for the year ending June 1, 1870.

Seven hydraulic claims are reported from Del Norte, one of which is located on Smith River, and the remainder at Happy Camp. They furnished employment for thirty-three men during an average of 8.1 months. The wages paid were $63 per month. An aggregate yield of $31,200 was the result, or $4 46 per hand per day. The Del Norte Mining Company at Happy Camp, employing twelve men for eight months, produced the largest amount—$15,000; and Lee & Co., working five men for five months, took out $5,000. The other claims yielded mostly less than $3,000.

From Siskiyou County forty-three placer claims are reported. They employed 129 men during eight months, and the total product was $103,600 for the year ending June 1, 1870. The average yield per day per hand was about $5. The claims of Simmons & Co., who employed eight men for six months and produced $8,000, and of J. Carroll & Co., who employed three men on an average for ten months, at Scott's Valley, producing $8,150, are the most prominent.

Three hydraulic claims, employing twenty-nine men during 4.1 months, on an average of $50 per month, are in operation. The total yield was $25,500, or an average per day per hand of $8 24, and the product was divided as follows:

The Etna Mining Company, employing six men, five months, produced	$5,000
Wright Brothers, employing twenty men for four months, produced	15,500
Young & Eastlake, employing —— men for —— months, produced	5,000

The quartz-mining interest is in its infancy, and has contributed only $6,500 toward the total product of the county. The only mines worked were that of the Scott Valley Mining Company, from which 167 tons of

quartz, yielding 100 ounces of gold, worth $1,500, were taken out by two men during one month's work; and that of Regans & Williams, which was worked with a small and varying number of miners for three months, and produced 312½ ounces of gold, worth $5,000.

In Lassen County new and very rich diggings were discovered in the summer by Haskins, Ehlers, and others. The locality is twelve miles south of the Siskiyou County line and forty-five miles from Susanville. Water was very scarce in the locality; nevertheless from $250 to $500 were taken out daily for some time. Great activity was expected in the winter, when water would be more abundant.

The population of Klamath, Del Norte, and Siskiyou counties is given by the late census as follows:

	Total.	Chinese.
Klamath	1,674	585
Del Norte	2,022	217
Siskiyou	6,848	1,440

DEEP PLACER MINING IN CALIFORNIA.

[The remainder of this chapter was prepared by W. A. Skidmore, of San Francisco, from personal observations and inquiries.]

The period of depression in this branch of mining which succeeded the comparative exhaustion of the shallow placers, and river and bar mining in the modern streams, has been followed within the past year by a season of renewed activity, caused in a measure by the success of many companies operating with the advantages of large capital, and by concentration of labor and the consolidation of large tracts of mining ground—the original owners of which, without such consolidation, could not afford the great expense of procuring outlets for their dirt and gravel by means of the construction of "bed-rock" or drain tunnels—but principally by the invention and adoption of numerous appliances and improvements in mining, the most important of which are the improved hydraulic nozzles and the new drilling and boring machines, which will be fully described hereafter.

SHALLOW PLACERS.

This term is generally used to designate the deposits of auriferous earth found overlying the country rock to a depth of from a few inches to six or eight feet, and to distinguish such deposits from those found in the ancient streams and rivers and deposited over a vast extent of country to a depth of from one to three hundred feet, during some remote period, by causes which, with the light we now have on the subject, can only be surmised. These are termed deep placers. It was in the shallow placers, at points where the banks of the modern streams had been denuded, near the foot-hills of the Sierra Nevada, that the first gold was discovered, and so prolific was the earth in the precious metal, that the product of gold, even by the primitive and rude methods of mining then in use, reached during the first five years after the discovery the sum of $180,000,000, nearly all of which was extracted from these placers.

The auriferous deposits which formed the early placers of California probably had their origin in two causes—the decomposition of rich

quartz ledges cropping above the surface, and the scattering of the liberated gold over the adjacent country—as at Auburn and Ophir, in Placer County, and in certain parts of El Dorado County; and the breaking up at places, by subterranean forces, of the ancient channels of the antevolcanic period, and the consequent distribution of their contents by the modern streams, as in many of the southern and central mining counties. Instances of this can be observed along the courses of the Feather, Yuba, and the several forks of the American River. At many points, as at Grass Valley and Nevada, where natural basins exist, both the above causes have been in operation.

The impression which generally prevails, both in California and abroad, of the entire exhaustion of the shallow placers, is unfounded. River and bar mining is still extensively carried on in many parts of the country, and in some cases, particularly in the northern counties, with remunerative results. In the central portion of the State, particularly on the north fork of the American River, fair wages are yet made, though here this branch of mining has been to a great extent abandoned to the more patient, though less skillful, Chinese. In parts of El Dorado and other counties lying to the south, a large extent of pay-dirt, varying in depth from three to ten feet, exists among the foot-hills, but cannot be worked on account of the scarcity of water, although known to be sufficiently rich to largely compensate any company that would incur the expense of bringing water to the ground. It is now contemplated to bring water to several such points in these counties, and it is not improbable that they may again see something of their former prosperity.

DEEP PLACERS.

The class of "diggings" known by this term embrace the ancient channels found throughout the State, from Plumas to Mariposa County—in many cases, as in Butte and Tuolumne Counties, covered with lava—and the immense detrital deposits of the northern and central region which are worked by the hydraulic system. Of the extent of this latter class we can form no intelligent estimate until the completion of the work now being carried on under the auspices of the State geological survey; but we know they cover a great part of the country lying west of the main range of the Sierras and between the head-waters of the Feather and South Fork of the American River. This includes an area one hundred miles in length by forty miles in breadth, and embraces parts of the counties of Plumas, Butte, Sierra, Yuba, Nevada, Placer, and a small portion of El Dorado. These deposits owe their origin to glacial or aqueous action of the geological period preceding the outbreak of the volcanoes of the Sierra Nevada and the upheaval of the Coast range. When these great changes in the topography of the country took place, the detritus of the more elevated portion was covered with streams of lava flowing from east to west, for a distance of from twenty to thirty miles from the craters. The waters, finding new channels—which run generally at right angles to the ancient streams—formed the present river system of the higher Sierras. The consequence was the denudation, breaking up and distribution of the ancient channels, where not protected by overlying crusts of lava, thus releasing from the storehouse of ages the golden sands which attracted hither the adventurous of all nations.

During a period of several years after the discovery of gold, the existence of the precious metals otherwise than in quartz ledges or shallow diggings was unsuspected. The early miners, lacking the benefits

of observation and experience, in vain followed up the modern streams to their fountain-heads, in the delusive hope of finding the "source of the gold." In no case was the "color" found above those points where subsequent examination revealed the breakage of the old channel system, or slides from under the lava crust, except at some points where unwashed gold was found in small quantities in the proximity of decomposed ledges of quartz. Subsequent exploration at these slides, and in gulches and ravines where the lava had been denuded, revealed the existence of ancient river beds at elevations of from 100 to 1,000 feet above the present water-level. These discoveries led to the construction of the great system of mining ditches, which, taking the waters of the streams from their fountain-heads, distributed them over the immense extent of ground worked now by the hydraulic process. By means of the facilities enjoyed from the use of abundant supplies of water, many points on the detrital deposits which were favorably situated for fall or outlet were worked, and hydraulic mining became for years the most remunerative branch of the business. In the course of several years of such extensive washings, however, the streams and cañons became filled and clogged with "tailings," which accumulated in such proportions as to effectually choke up all outlet, except for the brief season following the rains of winter, when the great volume of water would carry off a portion of the accumulated tailings, and admit of a few brief "runs." Then they became more limited, season after season, until this branch of mining was effectually stopped in some of the richest localities.

The washing of the surface dirt to a depth of from 100 to 200 feet revealed the presence of a hard white or reddish cement, composed principally of pebbles and boulders of quartz and metamorphic rock, dirt and sand, but not yielding to the action of water, as then used, in streams of from 1½ to 2½ inches in diameter. Through these strata of cemented gravel prospecting shafts were sunk to the bed rock, leading to the discovery at many places of a layer of blue cement of excessive hardness, composed of like material, and varying in thickness, in different localities, from 3 to 10 feet. This layer, which often proved fabulously rich, was compact and firmly cemented by chemical agency and great pressure, and required the use of powder and drills for its extraction, and of heavy stamps for crushing. These discoveries gave a fresh impetus to mining, and resulted in the construction of bed-rock tunnels for the extraction of the cement from the ancient river beds and the drainage of the ground. Many of these tunnels, as in Tuolumne, Butte, and near Forest Hill, in Placer County, were run thousands of feet under the lava, and through the rim-rock of the ancient channels. These enterprises were, however, not uniformly remunerative, for though the channel was generally found, the tunnels, which had been commenced and constructed without preliminary surveys, were often found to enter the channel above the bed of the stream, thus rendering them useless for extensive exploration and compelling their final abandonment. These various obstacles had a discouraging effect upon the mining interest, and a period of depression followed, lasting several years, during which the discovery of gold on Frazer and Salmon Rivers and of the silver lodes of Washoe, occurred—events which nearly depopulated the mining counties.

CAUSES OF DEPRESSION OF PLACER MINES.

The causes for the inactivity in past years of this branch of mining may be briefly summed up as follows:

1st. The injudicious system of locations permitted under early mining

laws and regulations, through the ignorance of the miners of the character, extent, and depth of the detrital deposits. These locations were generally made in claims of 100 feet frontage, running back to the center or backbone of the nearest ridge, regardless of the course of the deposit, such claims being too small to justify the expenditure by individual owners of the large sums necessary to construct tunnels for outlet and drainage of their ground.

2d. The filling and choking up with tailings, after a few seasons of washing, of the ravines, gulches, and rivers which served as outlet for the ground, thus preventing the maintenance of flumes of sufficient length and grade to disintegrate the hard cement found underlying the top dirt, and rendering imperative the construction of long tunnels to the nearest deep stream, requiring, in some cases, years of labor and the disbursement of large sums without immediate returns.

3d. The ignorance of the people and of capitalists of the unbounded mineral resources of their own State; the sudden and unhealthy excitement following the discovery of gold in British Columbia, and silver in Nevada; and the efforts of a portion of the press of California, in the interest of land speculators, to "write up" agriculture at the expense of mining.

4th. The uncertain tenure of mining ground under local mining regulations, which differed in every district, and afford no adequate protection to the purchaser of mining ground unless he remained in actual possession.

THE GOLD YIELD OF CALIFORNIA.

The year 1870 may be marked as the beginning of a new era of mining in California, indicating an increased yield for the future, which promises to continue for many years, and it is not improbable that the gold product for the next ten years may be brought up to an average of $36,000,000 per annum.* At the date of writing no accurate estimate can be made of the receipts of gold from California mines for 1870, as no separate records are kept at the San Francisco mint of treasure receipts, a large proportion of such receipts being in the shape of refined bars from the gold refineries. The receipts of gold dust at the mint have been principally from small companies working on the deep placers, and from river and bar mining, as most of the large companies have recently erected their own retorting and smelting furnaces, from which they send their crude bullion to the refiners, who keep no record of the locality from which the gold is shipped.

The following table of comparison of coinage at the San Francisco mint for the past four years will bear evidence of the increased gold product for 1870:

1867.	1868.	1869.	1870.
$19,370,535	$17,365,000	$14,365,550	$20,355,000

The coinage for 1870 exceeds that of any year since 1859, and it must be remembered that the past season, on account of its dryness, has not been an auspicious one for mining operations. The amount of

* This is Mr. Skidmore's estimate, not mine. I presume it refers to the total amount of gold received at San Francisco, not to the product of California alone.—R. W. R.

coin turned out by the branch mint in San Francisco during the year 1870 has never been exceeded but twice, viz: in 1855 and 1856. In the former of those years the coinage amounted to $21,121,752, and in 1856 to $28,516,147. The coinage for 1870 is $5,991,450 in excess of that for 1869.

PROSPECTS FOR THE FUTURE.

Many causes have operated to confirm me in the opinion that the future is bright with promise. A more lively interest is felt by capitalists in the examination and development of these dormant resources, and the information disseminated through the medium of the State geological survey, and the various reports of the United States mining commissioners, have not been without effect in turning the attention of the people to the vast stores of wealth at their very doors. One of the most encouraging features of future progress is the tendency to consolidation and coöperation on the part of owners of mining ground, who are availing themselves of the recent act of Congress to acquire a title in fee simple to the land by means of a United States patent. As an instance of the beneficial operation of this law, we may mention the fact that one company, the North Bloomfield Gravel Company, of Nevada County, are now applying for a patent to 1,500 acres of mining ground, lying between the Middle and South Yuba River. Should this act be liberally construed by the various land offices, and no expensive obstacles placed in the way of the miner seeking to acquire title, (as was the case in the operation of the act for acquiring title to quartz ledges,) much good will result to the State from the passage of this law.

Important improvements have been made in the manner of using water in the hydraulic diggings. Instead of projecting five hundred to one thousand inches of water through two or four pipes, the leading mines now run their water through one pipe by means of the recently invented hydraulic nozzles, and discharge it with immensely increased momentum and effect against the bank they desire to wash down, accomplishing greater results with less labor and expense, and enabling one miner to regulate the discharge of a thousand inches, in streams of six inches in diameter, by means of a lever, moving a nozzle which turns in any direction, with more ease and accuracy than three men could do it by the old process. So powerful is the force exerted by these large streams, under great pressure, that many cemented gravel banks which formerly required the use of powder blasts before washing, can now be cut down and removed by the action of water alone.

No less important is the application to mining operations in California of Leschot's Patent Diamond Pointed Steam and Compressed Air Drill, and other inventions having a like object.

Most of the extensive bed-rock tunnels in the State were commenced under the old and expensive system of large drills and blasting powder, requiring three men to each drill—two strikers and one man to turn the drill. Then followed the discovery of giant powder, bringing with it the use of the single-handed drill, which reduced the expense of tunneling from 25 to 33 per cent. The application of diamond-pointed borers (as they might more properly be called) promises still further to reduce these expenses to so low a figure as to render these once formidable enterprises practicable in every district.

The expense of running tunnels in California has varied greatly in different districts, according to the character of the bed-rock. At Smartsville, Yuba County, where the rock is a hard, flinty trap, the expense was formerly as high as $40 per linear foot. This was reduced

to $30 per foot by use of single-handed drills and giant powder, under the contract system. At North San Juan, Nevada County, where the bed-rock is a soft granite, the expense per linear foot has not been more than from $30 to $40. Near San Juan, where tunnels have been run, at the junction between the slate and granite, the expense has been reduced to $20 or less per foot. Near You Bet and Little York, where a soft slate occurs, the cost has rarely exceeded $10 per foot; but there are instances where such tunnels are known to have cost $60 per linear foot. These tunnels are generally 6 or 8 feet in height, and 4 to 6 feet in width—the one at Smartsville, now being run for the Blue Gravel Company, being still larger.

In another part of this chapter some account will be given of the operations of the diamond drill in California. It may reasonably be expected that when the compressed air attachment for these machines is completed, they will come into general use, and be instrumental in opening up hundreds of acres of rich ground which would otherwise remain undeveloped. Nearly one hundred of these machines are in successful operation in the Eastern States, being run by steam, which, as a motive power, is not adapted to our small but long tunnels, as the steam-pipes render the air hot and close; but this difficulty will be obviated by the use of a compressed air apparatus. The cost of these machines will not exceed (with compressed air power) $10,000, and they will bore inch holes at the rate of from one to two inches per minute in the hardest rock.

As these improvements are adopted, the amount and profit of this branch of mining increases, and the steady operation of these causes, including the facilities for the procurement of title to mining ground, will have a tendency to materially increase the gold product.

CEMENT MINING AND REDUCTION BY MILL PROCESS.

The ancient channel gravel claims worked exclusively through tunnels and shafts have not, as a general rule, proved remunerative for a few years past, although some mines of this character, of which we may instance those at You Bet, Nevada County, and some in the vicinity of Forest Hill, Placer County, have yielded enormous returns, at irregular intervals. The great obstacle to permanent success seems to be the "spotted" character of the channels, and the difficulty of tracing underground the sinuosities of the ancient streams, together with the cost of timbering, draining, hoisting, &c., incident to underground operations. At many places which have not been covered with the lava flow, or where the top dirt is denuded, the owners of this class of claims have suspended milling operations until they can wash off the overlying deposits (which will pay largely where water is abundant) down to the hard cement. They will then have the advantage of working this bed-rock with some degree of certainty in following the course of the channel, where the richest deposits may be expected, and save the expense of timbering, and much "dead work" in prospecting. In places, however, where the top dirt has been washed off, and where water-power is used for running the mills, this class of mining has been uniformly successful. The expense of mining and milling in claims of this character may vary from 75 cents to $1 per car load of 16 cubic feet, (equivalent to one ton,) as at French Corral, Nevada County, while in many claims between the North and Middle Forks of the American River, where long tunnels are run under the lava crust, and the mills are worked by steam-power, the average cost of milling and mining, per 16 cubic feet, will reach as high

as $2 or $2 25. Mines thus situated are rarely remunerative, except in seasons where a "strike" is made. An improvement has been made in this branch of mining by the substitution, at several mills, of coarse screens, with apertures one-quarter of an inch in diameter, instead of the one-eighth-inch screens heretofore in use. The result has been an increase in crushing capacity of 25 per cent., without affecting the product of the cement.

EXTENT OF THE DEEP PLACER DEPOSITS

The deep placers, as we have seen, are contained within certain geographical boundaries embracing a region of nearly 4,000 square miles, within which are found six of the prominent mountain rivers of California and their tributaries, to wit: the Feather, the North, Middle, and South Yubas, and the North and South Forks of the American River. The "divides" between these streams all contain enormous extents of detrital deposits, which have been discovered and opened at places where "slides" have occurred. The eastern extremities of these divides are covered with lava or volcanic ashes, and the western are lost in a series of low foot-hills, running into the Sacramento and San Joaquin Valleys, where the deposits are of slight depth, but, as a compensation, rich veins of quartz are found.

The most extensive deposits occur in the counties of Sierra, Placer, and Nevada. In Sierra County two belts are found running parallel with each other, in a northerly and southerly direction, embracing almost the total area of the county, but a great portion covered by the lava crust. One of these has the characteristics which have given it the name of the Great Blue Lead, from the colors and character of the cement found on the bed-rock. In Nevada and Placer counties, besides the existence of these belts, an intricate system of ancient channels and basins is found, calculated to confuse and bewilder the observer who is anxious to find evidence for his "old channel theory." Nevertheless, the Blue Lead is here unmistakably defined. In Placer County, between the North and Middle Forks of the American River, an enormous expanse of auriferous ground exists, incompatible with the theory of one or many ancient channels.

The most extravagant statements have been made by enthusiastic persons who have visited the region under consideration, and computed the extent of the gravel deposits and their richness. One estimate has placed the area of detrital deposits between the Middle and South Yuba Rivers at two hundred square miles. An acquaintance with the ground in question warrants me in the belief that such an estimate is greatly exaggerated.

Up to the present time no surveys having for an object the approximation of the extent of the deep placers have been completed, though such a work is now being carried on under the auspices of the State Geological Survey. The only map which pretends to indicate the detrital deposits is one of the Central Mining Region of California, compiled by A. J. Doolittle, in which he has relied more upon his personal knowledge of the country, in designating the locality of such deposits, than upon actual surveys. The map, however, is generally accepted as correct and reliable.

From the light at present thrown on the subject, the writer, if compelled to hazard an estimate of the area of the deep placers, would place it at between four hundred and five hundred square miles, with an average depth of 120 feet, and would feel confident that he had rather

understated than exaggerated the amount. When we compare this vast extent of ground with the limited quantity worked, we are justified in saying that in comparison to the undeveloped ground the labor of years has resulted only in extensive prospecting.

PROBABLE GOLD-PRODUCING CAPACITY OF THE DEEP PLACERS.

In making an estimate of the capacity for production of the deep placers we meet with still greater obstacles, on account of the difficulty of obtaining accurate statements of the yield of the ground. The entire extent of the auriferous ground between the Middle and South Yubas has been estimated to contain from 30 to 35 cents per cubic yard. This estimate has been based on the returns from ground worked in the vicinity of North San Juan, Nevada County, which, from the great natural facilities of this locality for running off vast quantities of dirt, cannot be taken as a criterion for other districts.

The operations of the American Company, at Sebastopol Hill (near North San Juan) afford the best means of making an approximation of the quantity of gold contained in a cubic yard of the auriferous deposit. The result of sixteen years' work shows that a production of between 25 and 30 cents per cubic yard has been reached. This would give a product, estimating on an average depth of deposit of forty yards, of the enormous sum of between $50,000 and $60,000 per acre. The ground of the American Company has an average depth of fifty-six yards, but this company, on account of its natural advantages of situation (which will be explained hereafter in a description of the ground) saves a greater proportion of its gold than any other hydraulic claim in California, and its ground is undoubtedly richer than the average.

The ground lying between Greenhorn Creek and Bear River, Nevada County, though it has yielded enormous returns to its owners, until the partial filling of its outlets by "tailings," has never reached an average of 25 cents per cubic yard; and at Gold Run, Placer County, one of the most productive regions of the State, the success of the miners is to be attributed to the quantity of ground washed, on account of its softness, rather than to its richness. These last-named localities possess the advantage of an abundance of water at low rates, prices ranging from 10 to 12½ cents per inch, while at North San Juan 16⅔ cents per inch is paid.

Between the North and Middle Forks of the American River, in Placer County, the ground has probably yielded a higher average per cubic yard than at any other locality. I am led to this conclusion from the great productiveness of this part of the country in proportion to the amount of water used, which here is very limited.

The cost of hydraulic mining, per cubic yard of dirt washed, will differ in the various localities, according to the price of water and the character of the bed-rock. Mr. Black, in an article on the resources of Nevada County, quoted in Ross Browne's report, placed it at 20 cents per cubic yard, but the writer feels confident that the estimate is too high by over fifty per cent., and that hydraulic ground yielding less than 20 cents per cubic yard will pay largely at any place in California.

IMPROVEMENTS IN HYDRAULIC MINING.

Hydraulic mining has made such rapid strides on the road of progess, and assumed such monster proportions in the past year or two, that now the vast magnitude of its operations serves to almost totally

eclipse every other branch of mining industry. The principal cause of this success, and the energy displayed by miners of this class, is attributable to the recent improvements made in apparatus or machinery, long needed, which would enable the miner to use a heavy, perpendiculary pressure of water with safety and economy, and at the same time place it within the power of a single operator to concentrate in one stream and effectually control a large body of water.

To fully understand the extent of these improvements, it will be necessary to state a few facts in relation to the primitive or old-fashioned method of conducting this work, and trace it step by step to its present perfect condition.

The object to be accomplished is to confine a body of water in a compact, continuous stream, to a certain point of egress, whence it will pass, with more or less force, in an almost solid column. This force will, of course, be governed by the relative height of the entering head of water above the discharge-pipe or nozzle. The stream so obtained is used to undermine banks or walls of auriferous dirt and cemented gravel deposits, and the greater the height or elevation at the point of supply, the greater will be the force and quantity of the water discharged; and the more those two powers (fall and quantity) are concentrated, the greater the amount of earth that will be torn down and removed, resulting in a proportionately larger yield of the precious metals. Having thus described the object, I will now speak of the apparatus used for bringing about these results.

Canvas hose was first brought into general use in 1853, and as the larger proportion of the mines worked at that time were quite shallow, and the dirt, as a general thing, soft, it was found to answer so well that several years elapsed before an effort was made to improve on it. Canvas hose is constructed about six inches in diameter, of very strong sail-cloth; will bear with safety from eighty to one hundred feet pressure, and discharge effectually a stream of water one and three-fourths or two inches in diameter. The material, however, which is composed of cotton, is very expensive, and rots rapidly, while, at the same time, it is ever liable to burst by the weight of water, and thus become a complete loss to the miner.

As the development of gravel deposits progressed, it was found that the materials of a large proportion of our richest mines were very difficult to disintegrate. These consist of a species of cement, and the working of the gravel beds demonstrated that greater fall or pressure was needed to enable the water to undermine and break up the gravel; and as canvas hose could not bear the necessary pressure, a substitute was found in sheet-iron pipe. This is constructed of various dimensions, from six to forty inches in diameter; but, in order to obtain a flexible discharge piece, it was necessary to retain a short piece of canvas hose, and in order to make it safe it had to be covered or bound up by a netting or cover of strong rope, which was both expensive and inconvenient. These difficulties combined succeeded in arousing the inventive ingenuity of the miners, and resulted in bringing to light the inventions known as the "improved hydraulic nozzles," the first of which was invented by the Messrs. Craig, of Nevada County—a county which has had the honor of inaugurating all the improvements in this branch of mining. These improved nozzles proved a complete substitute for canvas hose, and by their simplicity of construction, cheapness, and durability, met with an immediate, rapid, and extensive adoption by the miners throughout the State. This has enabled them to use with safety a sufficient head of water to work the hardest dirt or gravel rapidly and

cheaply, and at the same time to use a pipe of any size required, so as to run all their water in one stream, which alone nearly doubles its effectiveness, and besides places it under the control of a single operator. They gain in force, saving manual labor, and economizing in every way.

I will briefly describe two of these inventions:

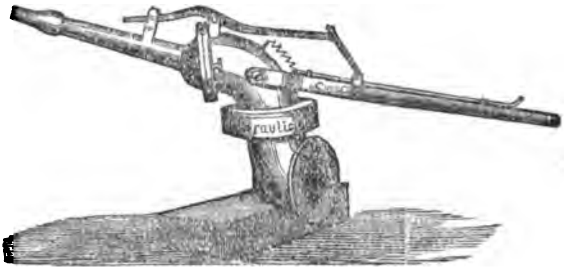
Craig's Globe monitor or Globe hydraulic nozzle.—This invention consists of a hollow ball or globe, with an opening at one side, into which

Craig's Globe Monitor.

enters the main feed or supply pipe, and one on top, out of which protrudes an elbow joint. One end of this elbow is attached to a socket, which revolves on the interior of the globe, and at the same time creates a water-tight joint; this joint enables the operator to change the direction of the stream from point to point at pleasure. To the other end of the elbow is attached the discharge-pipe, which may be of any size desired. The ball revolves entirely round horizontally, and up or down, at an angle of about forty degrees. This play has been found amply sufficient for all ordinary mining purposes, and causes a perfect stream to emerge at any point to which the nozzle may be directed. As a matter of economy, it not only places the water of seven or eight ordinary hose-pipes under the control of one man, but its durability is so great (one lasting a life-time) that its extra first cost is seldom noticed, it being in convenience alone worth more to the miner than the difference of cost of canvas hose. No canvas being used, it is not liable to breakage under heavy pressure, and saves the annual outlay for canvas, while the concentration of a larger body of water in one column has been found to nearly double the amount of execution in comparison with ordinary expenses. The proprietors, Messrs. R. R. & J. Craig, of Nevada City, manufacture four different sizes, the largest of which will run some 1,500 inches water, "miners' measure."* The Messrs. Craig have three United States patents upon the monitor and its improvements, and deserve great credit for developing so valuable an auxiliary to our mining industry.

*A "miners' inch" of water is generally accepted to mean the quantity of water which would flow from an aperture of one square inch, under the pressure of a steady flow of water standing six inches above the top of the escape aperture; consequently 1,000 inches of water (the amount now thrown through a 6-inch nozzle) is the quantity which escapes at the discharge-box from an aperture or gate 6 feet in length and 14 inches in height, under a pressure of 6 inches of water above the top of the aperture. The discharge-boxes are generally 6 feet by 6 feet, and 2 feet in height. The difference of elevation between the discharge-boxes and the "distributor" (from which the water is conveyed to the nozzle) is generally 200 feet or more—at Gold Run nearly 300 feet.

F. H. Fisher's knuckle joint and nozzle.—This machine consists of two elbows placed in reversed position when standing in right line, but made to revolve by a ring in which there is a series of anti-friction rolls, the ring being slipped down over the top of the lower elbow and then held in its place by a flange, bolted to the top of the lower elbow. The ring is then bolted to a flange on the top elbow, thereby connecting the two together and at the same time leaving the top elbow free to move around in a complete circle. When the water is let into the elbow the pressure brings the rolls up in the ring against the flange on top of the bottom elbow, allowing the top elbow to move around easily and without any friction except that of the rolls themselves. A piece of rubber packing placed between the flanges of bottom and top elbows, makes the joint tight by the pressure of the water against the ring. In the outlet or top elbow is a knuckle joint which gives the up and down motion to the discharge-pipe. It is a concave surface fitted to a convex one; the concave has an opening for the pipe to pass through. The pipe is screwed into the convex surface and will move up and down while the concave one is bolted firmly to the flange on the top elbow. The elbow and knuckle joint are made of cast iron from $\frac{5}{8}$ to $\frac{3}{4}$ inch thick. The discharge-pipe is made of No. 16 iron, 8 feet long, with cast-iron nozzle. The machine is operated by a lever 10 or 12 feet long with two arms, and attached to top elbow by trunnions. A lever is pivoted to the top of the upper elbow and attached on one end to the discharge-pipe by a strap inclosing the pipe and provided with two rolls on top for the lever to slip on. At the other end it is connected with the operating lever by a short upright lever made to work loose in its joints. Thus the up and down motion is imparted to the discharge-pipe by the rise and fall of the operating lever. By moving it to the right or left the whole machine except the bottom elbow is moved. A little device is attached to the lever to hold the discharge-pipe in position when the water is off. It is a catch working in a ratchet on the top elbow, attached by a rod running out on the lever so that the operator can put it in or out as the case may be. The pipe stands firmly in place when the water is on; the operator standing at the end of the lever can easily direct the stream to any point—good execution being done at a distance of 200 feet from the bank, thus securing safety of life from caves which are of so frequent occurrence and often fatal where small streams are used against high banks. These machines are made to throw streams of from 4 to 7 inches in diameter, and were invented by a citizen of Nevada County, Mr. F. H. Fisher.



Fisher's knuckle joint and nozzle.

ROCK-DRILLING MACHINES.

Besides the improvements in hydraulic machinery many other mechanical discoveries and improvements have been made during the past year, resulting in a large aggregate of practical benefits. Among these I may mention:

The Blatchley rock drill.—This machine, invented by Dr. Blatchley,

of San Francisco, and constructed at the Miners' Foundry, has only recently been brought to perfection, after four years of continuous and costly trial, during which every alteration and addition was made that the severest practical tests could suggest to the mind of the originator. A machine capable of doing work of this kind with expedition and economy has long been a desideratum in the mining regions, where we have so many tunnels to drive, and often through the hardest material. The Blatchley drill is an exceedingly powerful implement, and at the same time simple, inexpensive, and durable. It is but 30 inches long, 7 wide, and 10 high; weighing only about 100 pounds, apart from the drill, which is inserted after the machine is in position. It can be operated by hand, so little power is required to drive it. It can be attached to an engine or other motor at a distance, and the method of using it can be easily learned. For ordinary work it gives 300 blows, cutting 3 inches in granite, per minute, though this rate of speed and execution can be doubled with a corresponding increase of power. An ingenious method of transmitting power from the surface into the mine or tunnel below, insuring the running of many machines at small cost, has just been completed and patented by Dr. Blatchley.

Diamond-pointed steam drills, their application to mining operations in California.—These machines were first introduced on this coast by Severance, Holt & Co., in the early part of 1870, and used on Telegraph Hill, San Francisco, where holes were bored two inches in diameter and from 20 to 35 feet deep, for blasting purposes. These holes were made merely to show what the machines could do, and were bored 20 feet in from three to four hours; and 35 feet in less than six hours. The contractor, who was taking out the rock for the San Francisco bulkhead, and making holes of a corresponding depth, same size at the bottom, but much larger at the top, with hand-power, on the old-fashioned "churn"-drilling process, employed six men from twenty to twenty-five days to bore a single hole the same depth, at a cost of over $10 per foot. The machines were worked by two men, an engineer and fireman. The holes made by the "diamond drill" are perfectly round and of a uniform size, which makes them much more effective than those made by the old process. The contractor claimed that the amount of rock displaced by a blast put in one of those holes was eight or ten times greater than by the old system of drilling. Holes were made 3 feet deep in seven minutes.

The first deep boring done near San Francisco was at Mission Creek, through the same character of rock, for an artesian well. This hole was made 327 feet deep, and 3 inches in diameter.

In Tuolumne County the company bored prospecting holes near Don Pedro Bar and Tuttletown. At the latter place Messrs. Gould & Cooper bored seven perpendicular holes through talcose slate, porphyry, and sandstone, and cores were taken out showing the character of rock. The diamond drill made from 10 to 35 feet per day of ten hours. The holes were made from 30 to 157 feet deep.

At Carson's Hill, Calaveras County, the company used a machine on the "Union Mine," prospecting for the direction and value of the different leads. These holes were made from 120 to 317 feet in depth. The rock bored through was slate mixed with quartz. These holes were all bored at an angle of about 45°, and the machine made as high as 70 feet in a single day of ten hours, through slate with quartz streaks through it. In five hours 13 feet of white crystal quartz was bored. This was the hardest rock found in the mining districts.

Near San Rafael, in Marin County, on the premises of Mr. George

Worn, the company bored several holes 2½ inches in diameter and from 100 to 300 feet deep, for artesian wells. The rock here was of a very peculiar character, and generally very hard. It changed very often from sandstone, hard and close-grained, to a conglomerate of slate, volcanic rocks, flint and basalt mixed. This boring was very difficult, nevertheless the machine made as high as 24 feet in six hours.

The company have machines at the Pacheco Mine, Monterey County, for prospecting purposes, and in various other places in the State; also one in the White Pine district, and are constructing one to be run by compressed air for the Blue Gravel Mining Company of Smartsville, Yuba County, California, a description of which will be found under the heading of "The Smartsville Hydraulic Mines." Should this machine prove a success in point of execution and economy—and recent experiments at Smartsville leave no doubt on that subject—we may reasonably expect the construction of many extensive drain tunnels in California, which were formerly considered impracticable on account of the expense.

These tunneling machines are made to suit the size of any tunnel, as per order. The compressors required to run one of these machines in a long tunnel are arranged to work by any power convenient, and do the double duty of working the drilling machine and ventilating the tunnel at the same time. Most of these machines are made to run by steam, but those for tunnels, shafts, stopes, &c., are intended to have compressed air for the motive-power. Prospecting machines with horizontal boilers on wheels are constructed which can be used to bore prospecting holes 1,000 feet, if necessary, taking out a core the entire depth, and having sufficient power to lift the refuse matter out of a shaft, or do any work in which strong power is required, without disturbing the progress of the drill in the least.

The Von Schmidt diamond borer.—Colonel A. W. Von Schmidt, of San Francisco has invented and is now constructing a drilling machine, or, more accurately speaking, a tunnel borer, which unites all the excellent qualities of the diamond drill with many novel features which promise to make it a greater success than any machine now in use for driving tunnels. The inventor considered that the great obstacle to rapid progress in running tunnels has been the resistance offered to blasts in a solid face of rock, and for the purpose of overcoming this difficulty has constructed a machine which will cut a circular slot in the face of the tunnel, 24 feet in circumference, 2 inches in width, and 3 feet in depth. At the same time a blast-hole, 2 inches in diameter and of same depth, (3 feet,) will be bored in the center of the face of the rock. The face of the tunnel now presents the appearance of a huge grindstone, set up on edge, and attached on one side to the solid rock out of which it is cut. The blast is put in the center hole, and the resistance of the sides having been overcome by the cutting of the circular slot, a single blast will take out rock to the depth of the slot or cutting on the sides. The machine, which has been drawn back while the blast is discharged, is now advanced against the face, when another slot is cut with like results. Allowing a reasonable time for firing the blast and clearing up the débris, the machine is expected to cut a smooth tunnel, 8 feet in diameter, at the rate of 14 feet per day. The cutting will be done by twenty-four diamond drills revolving on the periphery of a cylinder 8 feet in diameter, at the rate of eight hundred revolutions per minute, while the cylinder itself revolves once in a minute. The drills are set in motion by a disk at the back of the cylinder. The machine will be run by compressed air, and is intended to cut the tunnel of the Lake

Tahoe Water Company, a distance of two and a half miles through the granite of the Sierra Nevadas, from Lake Tahoe to the North Fork of the American River.

A writer in the Commercial Herald of San Francisco thus sums up the effects of the introduction of these improved mining appliances: "It is hardly possible to overestimate the importance of these inventions in their bearing on certain of our mining industries. The great item of cost, and, what is almost equally to be dreaded, of delay, in opening up our vein-mines, old river channels, and gravel-beds—the sources of our greatest and most enduring mineral wealth—have been the excavation of the tunneling necessary to reach and work them. Some of the tunnels driven to open up and drain the last two mentioned classes of deposits have cost enormous sums, requiring often from five to ten years for their completion; and, although when finished these mines are apt to prove very profitable, few men care to embark in enterprises directed to their development, with the prospect of having to wait so long for returns—this, rather than the cost of these works, even when prosecuted by hand-drilling, being the deterring motive. With the introduction of these drills, lessening so much the cost, while it almost annihilates this major objection, we may look for a great extension of these several kinds of mining, increasing materially the value of such properties, and adding proportionally to the available wealth of the country."

Having given a general review of the condition and prospects of placer-mining, I will proceed to a description of some of the most prominent districts and the mines found therein. In the description of mines I have selected those which may be considered as representatives of their districts, with no intention to disparage the merits of equally important claims in the same vicinity.

THE SMARTSVILLE HYDRAULIC MINES.

These mines are situated among the foot-hills of Yuba County, near the south bank of the Yuba river, about eighteen miles east of Marysville, and are noted for the gigantic character of the engineering works constructed for their development, and the princely incomes enjoyed by their owners. The mining ground here consists of a strip of auriferous deposits two miles in length by a quarter of a mile in width, overlying an ancient channel, and having an average depth of 240 feet. The elevation of the bed-rock above the water level of the Yuba River is about 500 feet. This river runs nearly parallel with the course of the ancient stream, from which it is less than one mile distant. The consequence is that the companies working this deposit have been compelled to run long tunnels with a slight grade, and do not possess the natural advantages for the construction of dumps and undercurrents, which form such an important feature in saving the gold in hydraulic operations. The whole extent of this ground is now owned by six or seven companies, each having separate bed-rock tunnels in the course of construction and nearly completed—the most noted of which is the Blue Point Gravel Company's tunnel, the largest and most expensive undertaking of the kind in the State. It is not improbable that there is as much rich ground in the State embraced within a like area, but none which has been so systematically worked, and yielded such large returns.

Mining in this vicinity was commenced as early as 1849 and 1850, though at that time confined to the banks of the Yuba River. Subsequent exploration revealed the existence of the gravel ridge, but after

working on it to a depth of from two to four feet a hard cement was encountered which could not be worked, by the primitive mode of mining then in vogue, with returns sufficient to pay the miners, and for a time the deposit was considered exhausted and attention again directed to the partially worked-out bars and banks of the Yuba.

In the fall of 1854 attention was again directed to the prospecting of the rich placers of Sucker Flat. Shafts were sunk on what is now known as the Blue Point Mining Company's claims to the depth of some fifty feet, passing through good pay-ground and striking rich gravel similar to that found in the bed of the Yuba River, which proved to be the gravel of an ancient river channel. Prospecting was then actively commenced in every direction. A shaft was sunk on what is now known as the Blue Gravel Company's mine, striking the same gravel as that found by the Blue Point Company. It required a large extent of ground to justify the running of a bed-rock tunnel to drain and work these deep diggings, and the Blue Gravel Company was formed by the consolidation of several small companies into a corporation which commenced a tunnel, making but little progress upon it until the present owners became interested. After some eight years of incessant toil they completed the tunnel in 1864, from the working of which several parties realized large fortunes, and the mine is still producing handsomely. This tunnel proved too high to work the old river channel to the bottom—there being some thirty feet of gravel below the present working level, to open which a second bed-rock tunnel, 1,500 feet in length, is now being constructed, two-thirds of which is already completed.

For the prosecution of this work the diamond drill will be used, as that invention has been tried in an experimental way, and found to accomplish all that was claimed for it, but the steam-power used was not adapted to tunnels of this size and length, on account of the excessive heat generated by the pipes, which carry the power from the mouth of the tunnel to the drills. To obviate this difficulty, the San Francisco agents of the diamond drills are constructing a machine to be run by compressed air. This machine will set on a truck about three feet wide and four feet long. It has a frame reaching to the top and sides of the tunnel on which the drills are run in such a manner that the rock or face of the tunnel can be pierced at any place, or any angle desired, without moving the truck. One or all of these drills can be used at a time. There will be a crank geared to the wheels, so that one man sitting on the machine can easily run it up to the face of the tunnel and back in a moment. This machine will cost about $10,000, and will bore holes one inch in diameter in the hard rock of the Blue Gravel Company at an average rate of an inch per minute.

A contributor of the Overland Monthly (August and September numbers, 1870,) in a series of papers descriptive of these mines, makes the following statement of the product of the Blue Gravel Company's mine from the time of opening up to May, 1870: "This mine commenced operations in 1853, and during the nine succeeding years the amount taken from it was $315,000. This was prior to and during the building of the main tunnel, and was all used for current expenses. In 1864 the tunnel was completed, and the showing becomes more favorable; for, during the forty-three months that followed, the amount was $837,000, or an average of $19,465 51 per month. The net earnings during the same time were $627,000; the cost of operating the mine being $5,000 per month, with $61,000 used for improvements. From 1868 to 1870, or about three years, the amount (given approximately) will hardly equal the former average. Taking $16,000 as the monthly product, which is

probably a moderate estimate, we have $576,000. Granting this estimate, the gross product of the mine, from 1853 to 1870 and date, is $1,728,000."

Lying to the eastward of the Blue Gravel Company's claim, we find the ground of the Smartsville Hydraulic Mining Company. This company was formed by the consolidation of numerous claims which had been partially worked, and was incorporated under its present name about the year 1868, with a capital stock of $200,000, none of which was called in, as the surface workings realized enough for current expenses, pending the construction of a tunnel for outlet. They were about one year in preparing for extensive operations and made their first "run" in 1869, since which time the following "clean-ups" have been made:

April, 1869	$11,506
July, 1869	30,410
December, 1869	49,062
March, 1870	48,970
June, 1870	54,662
Total	194,610

The dividends of this company for the present year, up to date, (October, 1870,) have aggregated over $50,000.

The mines of Timbuctoo, on the western extremity of the Smartsville deposit, have been worked for a longer period, and though not now equally productive, have been estimated to have yielded $2,000,000. Recently, however, an enterprise has been inaugurated which, from its success, promises to bring these claims again into notoriety. Mr. O'Brien, one of the largest land-owners in this vicinity, has erected on the ground of the Pactolus Company a 10-stamp mill, for the purpose of cleaning up the bed-rock and working the cement which the water has not carried off. The mill is run by water-power, with a turbine wheel, and the total expense of running, labor included, is about $40 dollars per day. In cleaning up bed-rock a number of men are employed, who pick down the rock to a depth of a few inches, where crevices occur, and sweep up the dirt and rock with hand-brooms of cane, until it is as clean as a floor. All this dirt, together with the harder cement, which is broken up by white labor, passes through the stamps, and in this manner fifty or sixty tons per day are crushed. The gold-saving method is the simplest—amalgamation in battery, copper-plate, riffle-boxes, and a tail sluice. As a large portion of the bed-rock is exposed here from former hydraulic washing, all the work is carried on in open air. The first "clean-up," for eight days' run of twenty-four hours per day, (made October 20, 1870,) yielded 195 ounces of retorted gold, worth about $18 60 per ounce, leaving a handsome profit after paying for the mill, which cost only about $2,500.

There are about 250 or 300 miners employed in this vicinity at the present time, at wages varying from $3 to $3 50 per day. The total product of the Smartsville mines has been estimated at $4,000,000 up to 1870. The extensive system of works being carried on here will insure the continuance of mining for at least twenty years more.

The Excelsior Canal Company own the principal water privilege here. They have about one hundred miles of ditch; the longest in any one stretch, however, is thirty-three miles. In the driest season they furnish 3,000 inches of water; in winter, 6,000. They also own extensive and valuable mining ground.

The Blue Point Gravel Company's bed-rock tunnel.—Probably the most important mining enterprise of this nature in this State, on account of

the great extent and richness of the ground for which it will be an outlet, and the magnitude and expensive character of the work, is that being carried on at Smartsville by the Blue Point Gravel Company. This work, although projected for a long time, was not commenced until February, 1867. In order to make a certainty of being deep enough to work the old river channel to the bottom, the tunnel was commenced as low as practicable to give sufficient dump at the river for tailings. This brings the Blue Point tunnel into the old river channel, sixty feet deeper than the Blue Gravel Company's present working level, and one hundred and ten feet deeper than the present level of the workings of the company. This tunnel is 2,270 feet in length, six feet wide on the bottom, and eight feet high, the entire distance through hard, flinty trap-rock. Two shafts were sunk on the line of the tunnel to the grade, one 123 feet in depth; the other 138 feet in depth. From these shafts the work was carried forward on both faces of each shaft, and from the mouth of the tunnel—making five working faces—the rock and debris being hoisted through each shaft to the surface, by an engine and whim erected for the purpose. During the first year the work was carried on by contract from $34 to $45 per linear foot. The contractors, using common blasting powder, made such slow progress at times, six men making only ten feet in a month, that upon the introduction of giant powder they were released, the work being taken in hand by the officers of the company. They employed six men on each face with single-hand drills, using giant powder. The men were divided into eight-hour shifts, one set not being allowed to leave until relieved by the next set. In this manner the hammers were never allowed to stop, either night or day.

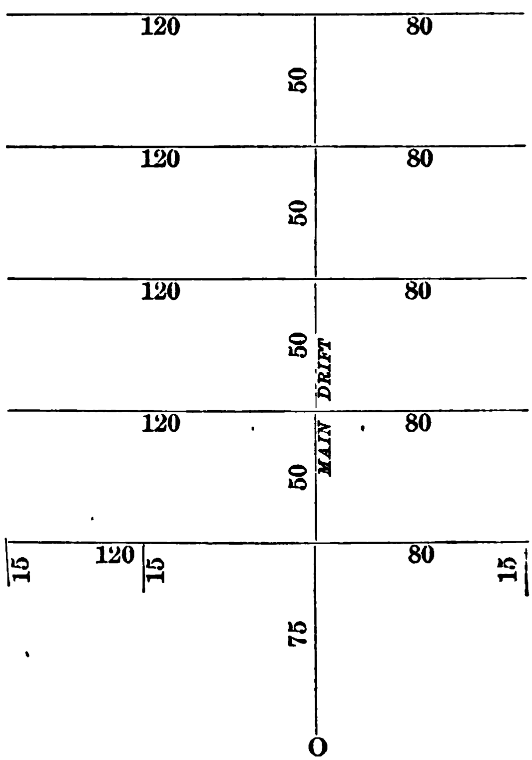
This work was so far completed in November, 1870, as to permit the raising of a shaft in which gravel was struck. The tunnel will however be carried some 400 or 500 feet farther, so as to reach the center of the channel.

The flume extends from the head of the tunnel to the bank of the Yuba River, into which the tailings fall, a distance of 4,650 feet. That portion of the flume which is in the tunnel is 42 inches wide and 26 inches deep; that portion outside the tunnel is 48 inches wide and 30 inches deep—the whole having a grade of one-half inch to the foot. The flume is lined with the hard rock taken out of the tunnel for a depth of one foot. This lining, it is expected, will last for six months; it will be taken up and turned after the first run.

I am indebted to Mr. Lyman Ackley, of Smartsville, secretary of the Blue Point Gravel Company, and one of the earliest miners of this district, for the following details of this extensive operation: "In prosecuting this work 9,000 pounds of steel drills have been worked up; nearly 10,000 bushels of coal for smith-shop; 1,327,900 points sharpened on drills; 94,000 feet of lumber used in work-shops, out-buildings, &c.; 600 kegs of blasting powder; 275 pounds of nitro-glycerine; 600 boxes of the best candles; 4,400 pounds of giant powder; 65,000 feet of fuse; for engine and foundery work $5,175 has been paid; 4,400 feet of the flume are lined with quarried rock 12 inches thick; 140,000 feet of lumber was used to build the flume; it will require 8,000 pounds of quicksilver to charge the same; 800 inches of water will be used on the mine per day, at a cost of $80 per day. The cost of these entire improvements is $150,000."

Among other bed-rock tunnels now in progress near Smartsville we note: The Pactolus, 800 feet, nearly completed; Pittsburg and Yuba River Mining Company, 1,700 feet, half completed; Blue Gravel Company, 1,500 feet, two-thirds completed.

Powder blasts.—One of the characteristics of mining operations at Smartsville is the use of large quantities of powder in blasts for the purpose of breaking up the cemented banks preparatory to washing them off. Blasts of 200 or 300 kegs are of almost monthly occurrence, but blasts of such dimensions as the one exploded in December, 1870, by the Blue Point Gravel Mining Company, in which 2,000 kegs of powder were exploded, are sufficiently rare to merit a detailed description. The bank to be raised in this instance was 73 feet deep, 275 feet long, and 200 feet wide. The annexed diagram will convey some idea of the manner in which the powder was distributed:



The ring on the diagram represents the termination of the incline from the tunnel, 73 feet below the surface. From this point a main drift was run, with cross drifts as laid down in the diagram—each drift being 3 by 4 feet in dimensions. The blast was discharged by a galvanic battery, for which purpose wires were carried through the main drift—going in on one side of the cross-drifts, thence passing out through the drifts on the opposite sides. A cartridge, connected with the wire, was then placed in a keg of powder in each of the cross-drifts—there being ten points at which the powder was fired simultaneously. The heads were taken out of the kegs of powder—of which 2,000 were used in this blast—equally distributed through the drifts. The mouth of the main drift to the first cross-drift was then firmly tamped, leaving a large open space in the balance of the drifts, which greatly increased the explosive effects of the powder, and the blast was fired. The result was, that the entire mass of earth, comprising 150,000 cubic yards, was raised from 6 to 10 feet and thoroughly loosened. The first "fifty days' run" after this blast yielded a very large return of gold. From 100 boxes (1,200 feet of flume) at the head of the tunnel, $42,260 was taken, leaving 230 boxes of the lower end of the flume untouched.

BETWEEN THE MIDDLE AND SOUTH YUBAS.

The easterly extremity of the Smartsville deposit is found at Mooney Flat, one-half mile from the grounds of the companies above described. From this point to French Corral, on the north bank of the South Yuba, distant ten or twelve miles on an air-line, there are no surface traces of the ancient channel. It is probable that the gravel range extending

from French Corral through Birchville and Sweetland to the Middle Fork of the Yuba River, near North San Juan, is identical with the Smartsville deposit, and that between Mooney Flat and French Corral it has been broken by the South Yuba, which runs through a gorge nearly 1,600 feet lower than the bed-rock of the ancient channel at French Corral. The fact that the deposit does not make its appearance between the south bank of the South Yuba and Mooney Flat, may be accounted for by taking into consideration the denuding action of Deer Creek, once a powerful stream, which runs on about the same level as the bed-rock of the ancient channel. The eroding action of these two streams has undoubtedly broken up and scattered the ancient channel deposit between the points above named. From French Corral to Moore's Flat, a distance of nearly thirty miles, between the South and Middle Yubas, we find a series of mining towns, the most noted of which are North San Juan and North Bloomfield, the latter place being known in early days as "Humbug." The auriferous deposit is not, however, continuous, and the deposits do not belong to the same system—the lower one coming in from Camptonville and the upper one from Snow Tent—the latter being covered with volcanic matter.

French Corral.—This locality has been worked from a very early period in the history of mining in Nevada County, and has proved uniformly rich. The width of the auriferous deposit is about 1,000 feet, with an average depth of 150 feet—130 feet of which is hydraulic dirt, the balance being cemented gravel of sufficient hardness to require crushing. The bed-rock is granite and slate, with narrow seams of quartz at the junction of these formations. Water is brought from Shady Creek, a distance of ten miles, through a ditch having a capacity of 2,500 inches, and which cost, with its reservoirs, at least $150,000. Water is sold at 12½ cents per inch. The ditch is owned by W. M. Eddy & Co., who also conduct the most extensive mining operations in this locality. They own 1,800 feet on the channel, and use 1,000 inches of water per day, running their dirt through a tunnel 1,000 feet in length and 2,500 feet of flume. They have also a fifteen-stamp mill for crushing the cement. Two other mills are in operation here—the Empire, twenty stamps, and the Kansas Company, ten stamps. The latter company are now taking out between $400 and $500 per day. Eddy & Co.'s mill has fifteen stamps, of 650 pounds each, run by a "hurdy-gurdy" wheel 12 feet in diameter, using 75 inches of water under a fall of 146 feet. This company has been using one-eighth-inch screens, but propose to change them for screens having quarter-inch apertures. This will permit the escape of the small pebbles, and will increase the crushing capacity of the mill from eighty to one hundred tons per day. One of the companies operating here has tried this experiment with satisfactory results, having increased their crushing capacity 25 per cent. without any diminution of the product per ton. The gravel crushed in Eddy & Co.'s mill has averaged between $4 and $5 per ton, and the expense of milling and mining has not exceeded $56 per day, or 70 cents per ton, (or 16 cubic feet.) The cement is loosened by powder blasts and the mining carried on above-ground. For this purpose, powder drifts are run with single hand-drills, and fine powder used in the blast holes. Mr. Eddy estimates the advantages of this over the old system (large drills and coarse powder) at fully 30 per cent. The construction of two bed-rock tunnels is in contemplation here, each of which will be from 1,600 to 1,800 feet in length, and will debouch on the South Yuba River. On account of the many seams found in the bed-rock, the cost of running tunnels here rarely exceeds $15 per linear foot. The estimated

gold product of French Corral for 1870 is $200,000 and the same amount may be anticipated for 1871. From French Corral to Birchville, a distance of two miles, less than one thousand feet of the bed-rock has been stripped, and it is estimated that not more than one-tenth of the surface dirt has been run off.

Birchville and Sweetland.—At Birchville the Bedrock Tunnel Company have just completed a tunnel from the Middle Yuba 2,600 feet in length, at a cost of $36,000. This company do not own enough surface ground to remunerate them for this extensive work, and until the surface ground and the tunnel are owned by one company but little work will be done at this place, though the ground is known to be rich. At Buckeye Hill, near Sweetland, the Buckeye Hill Mining Company, an English corporation, are carrying on extensive operations, with good prospects for large returns for 1871.

North San Juan.—This was formerly one of the most populous mining towns of Nevada County, but is now suffering from the stagnation incident to the exhaustion of the most accessible ground. There is yet much ground to work, but the present price for water—16⅔ cents per inch—does not afford remuneration to small owners, and many claims are passing into the hands of the ditch company. When the claims here shall have been consolidated, extensive operations will be resumed. During the past season only four claims have used water.

The American Company's claims.—The beneficial effects of consolidation may be illustrated by the success which has attended the operations of this company. The grounds of the American Company are located on Manzanita Hill, about one and a half miles west of the town of North San Juan. Commencing at the bluff overhanging the Middle Yuba, their claim runs 4,000 feet in a southerly direction—the general course of the channel being from north to south, and the grade of the old river-bed falling at the rate of 90 feet to the mile. The width of the pay dirt is from 300 to 450 feet, with an average depth of 175 feet from surface to bed-rock. The bed-rock is granite, and has a well-defined seam or crack running through it, from north to south, near the middle of the channel, and penetrating to unknown depths. This seam has been found 800 feet below the bed of the old channel, at a point where the main bed-rock tunnel has been commenced; and the various tunnels of the company, commencing on the hillside overhanging the Middle Yuba, have followed it, thereby diminishing the expense of running these tunnels from $40 to $15 per linear foot. The ground of this company was worked as early as 1853, but it did not pass into the hands of the present owners till 1863, when additional ground was purchased from time to time, at an expense of over $140,000, until the present extensive tract was acquired. This tract has a superficial area of about forty-two acres, and, estimating its average breadth at 450 feet, and depth at 175 feet, would give 11,597,100 cubic yards of auriferous dirt. Considerably less than one-half of this immense tract has been run off and has yielded $1,000,000, of which $400,000 has been profit. Estimating the product of the remaining ground at 28 cents per cubic yard, which is lower than the estimates of Professor Silliman or Professor Lauer for this mining region, and consistent with the past results of the working of the company, I am warranted in the belief that this claim will yet produce $2,000,000, of which more than one-half will in future be realized as profit. Even with the present improvements in this branch of mining, it is not probable that the undeveloped ground of the company can be washed off in less than sixteen years, without taking into consideration the lower grade of dirt left on the sides of the channel, or the cement

on the bed-rock which requires crushing. The company are now running from 500 to 800 inches of water per twenty-four hours, using four two-and-a-half-inch streams and a "Craig Monitor" nozzle of six inches diameter, as occasion requires. Water here is an expensive item, costing $16\frac{2}{3}$ cents per inch; but this company have an arrangement by which they pay $12\frac{1}{2}$ cents per inch for the excess over 500 inches used in twenty-four hours. Since opening the ground they have constructed over 6,000 feet of tunnel, and have laid nearly 10,000 feet of flume, of which 6,000 feet is now in use. These tunnels, commencing at the highest, are of the following dimensions: No. 1, 300 feet; No. 2, 600 feet; (these two are no longer used, having run off all the ground they opened;) No. 3, 1,800 feet; No. 4, 2,500 feet. The present washing is through the two latter. Tunnel No. 5 (the lowest) will be the longest, and will open the entire ground of the company. It was commenced, on the seam or crack above referred to, about 200 feet above the level of the Middle Yuba, and will have a total length of nearly one mile. It will be 7 feet in height, from roof to bottom of flume, and 5 feet wide. It rises from the mouth at the rate of one foot in sixteen, and will strike the gravel near the back line of the company's ground. One thousand feet have been completed, (Nov. 1, 1870,) and contract let for one thousand more, at $15 per linear foot. When 3,500 feet have been run, a shaft will be raised, a flume put in, and ground will be run through it, but the main tunnel will be carried on slowly to completion. The American Company has extraordinary facilities for saving its gold, by reason of its natural advantages of location. The northern extremity of the ground terminates on a bold bluff overhanging the Middle Yuba, and from 800 to 1,000 feet above that stream. The company have availed themselves of this advantage by the construction of a system of dumps and undercurrents, of which there are twenty-five—some of the dumps having a perpendicular fall of 20 feet or more, followed by the most improved undercurrents. As the term "undercurrents" is often used in the description of this class of claims, a brief description will be *apropos*. They consist of a set of side flumes, from 10 to 15 feet in width, arranged alongside of the main flume, which is opened at intervals, where a sufficient fall can be had, and close to the mouth of the opening, open riffles, made of heavy iron bars, are placed, through which descend the fine gravel and flour gold into the undercurrent, while the larger masses pass on through the main flume until they are sufficiently broken up to pass into the next undercurrent. The undercurrent is so arranged as to be wider for the first few feet, causing the water to spread and run slower, and then the undercurrent, being heavily charged with quicksilver and completely riffled, naturally catches the gold. In some claims a succession of these undercurrents, for half a mile or more, exists, and the last often pays from $100 to $300 per year for cleaning up. In consequence of these facilities a greater proportion of the gold is saved here than in any claim which has come under our observation. The total length of flumes is 6,000 feet, to charge which 1,600 pounds of quicksilver are used, at a cost of between $1,100 and $1,200. The company have their own furnace for retorting and melting, and turn out their product in bars, which are sent to San Francisco to be refined. They have also an eight-stamp mill, run by water-power, for crushing their cement. The mill will crush about forty tons per day, but is not in constant use. Chinamen are employed to clean the bed-rock, which is picked down a few inches and swept clean with hand-brooms. Besides the Chinese, from sixteen to twenty white men are employed. The underlying gravel and cement

is very hard in places, and requires the use of blasts. An average of 1,000 kegs of powder is used for this purpose, at a cost of $2 80 per keg. One of the objects of interest at this claim is the great "pot-hole." This hole has been worn in the solid granite bed-rock of the old channel by the action of a rapid current turning a large stone of some harder material than the granite. The hole is the shape of an inverted cone—six feet in diameter at its mouth, and tapering to a diameter of six inches at the bottom, a distance of fifteen feet. At the bottom was found a round stone—probably the same one which, commencing at the top, wore its way downward by attrition, reducing its size from several feet in diameter to a few inches. It would be an interesting problem to ascertain the length of time the stone was occupied in this process. Among the many ingenious contrivances introduced here is a set of signals, twelve in number, communicating by ropes between the mouth of the lower tunnels and the men engaged in piping on the bank above. By the simple movement of a hand on a dial, any one of twelve signals is instantaneously shown on the roof of the mill, where it may be seen for a distance of half a mile. By this means the water can be shut off without sending a man a half a mile to deliver a message from the flumes. The owners of this claim are nearly all practical miners, and a majority of them work on the claim, which is superintended by Mr. T. S. Crall, who opened the ground in 1853, and has been one of the largest owners. Statistics of interest relative to this claim were furnished last year by Anson B. Swan, and will be found on page 58 of Report for 1870. The American Company's claim is one of the most valuable mining properties in California, and its success has stimulated more active operations in this branch of mining.

North Bloomfield and vicinity.—Ascending the ridge between the South and Middle Yubas, we lose the gravel range of French Corral and San Juan, which has been broken off by the Middle Yuba, and, passing over a strip of unproductive ground between San Juan and Shady Creek, we find the second or higher deposit of the "divide," which extends from Moore's Flat to Cherokee, a distance of about fifteen miles, and has a width of from two to four miles, covering nearly the whole ground between the two rivers. The higher portion of this deposit has been covered with lava or volcanic ashes, and the lower portion has been worked until the outlet has been filled by the accumulated tailings, necessitating the construction of long bed-rock tunnels, to empty in either the Middle or South Yuba before this vast extent of ground can be properly worked. An illustration of the extent of these accumulations is afforded at the crossing of Shady Creek, near Cherokee. At this point there formerly stood a saw-mill on the banks of the creek; the boilers of this mill were supplied by a water-tank which stood higher up on the bank of the stream. The tailings from above so encroached on the mill that it was rendered useless and taken down; the tank, however, remained, and the timbers of which it was composed are now seen cropping up above the tailings a distance of several inches. Another "run" will completely obliterate all traces of this landmark of early times. The depth of tailings here cannot be less than 70 feet. The towns of Cherokee and Columbia Hill are fast decaying, although surrounded with rich ground, and will never know their former prosperity till capital comes to the rescue and buys out the present owners.

Among other well-known localities in this vicinity are Badger and Grizzly Hills. The distance from Badger to Grizzly Hill is seven miles; a heavy gravel deposit covers the whole distance, from one to five hundred feet deep, and from one to four thousand feet in width, and, so far

as developed, very rich. There are but two places in this vast deposit (Badger and Grizzly Hills) where it can be opened to advantage. Badger and Grizzly Hills are the keys to this whole deposit. The want of capital has so far prevented its opening. The Badger Hill and Cherokee Mining Company (an incorporated company) is now working on Badger Hill. At Columbia Hill the Union Company are running four hundred inches of water from the North Bloomfield Company's ditch with encouraging results.

North Bloomfield Gravel Mining Company.—This company is a San Francisco corporation, and is composed of some of the wealthiest residents of that city. They have acquired by location and purchase 1,500 acres of mining ground, for which they have obtained a patent under the recent act of Congress. If we estimate that 1,200 acres of this tract is available mining ground, with an average depth of 180 feet—and this is not too high an average—we find that this company has 348,480,000 cubic yards of auriferous dirt and gravel, of which not more than 400,000 or 500,000 cubic yards have been removed. At 20 cents per cubic yard, (which is about the average yield of this region,) this ground has a producing capacity of $69,600,000. In making this calculation, it will be borne in mind that while much of the surface dirt will not yield over a few cents per cubic yard—perhaps not more than enough to pay the expenses of running off—we can safely put the lower strata at 20 cents per cubic foot, or $5 40 per cubic yard. The following account of the operations of this company is taken, by permission, from the Mining and Scientific Press of San Francisco, to which it was furnished by the officers of the company: "The North Bloomfield Gravel Company have constructed a ditch from Big Canyon Creek to Bloomfield, a distance of forty miles, with a carrying capacity of 3,000 inches. This ditch has cost about $500,000, and is the best constructed and most substantial one in the State. They have also constructed a dam across Big Canyon Creek at Bowman's Ranch, 65 feet high and 215 feet in length, giving them a reservoir capable of retaining 400,000,000 cubic feet of water. In addition to this immense supply of water, the company own several important water rights in the line of their ditch, which afford a large amount of water during the rainy season. They also own the Rudycan reservoir, formerly owned by an English company, distant thirteen miles from the line of their present ditch. This is the largest reservoir in the State, and cost the English company over $100,000. From Bloomfield this company have constructed another ditch, seven miles long, to Columbia Hill, to supply water to the Union Gravel Mining Company, a majority of the stock of which is owned by the North Bloomfield Gravel Mining Company. The mining claims of this company are at present fitted with pipes, &c., costing some $40,000. Their network of mining flumes is about one and a quarter miles in aggregate length, varying in width from 40 to 72 inches. When these claims are running their full capacity, they will use three monitors, each capable of carrying 1,200 inches of water; also what is known as a goose-neck, carrying some 600 inches of water. These pipes are used under a head of 300 feet, and it is estimated that the capacity of the work is an ability to mine 100,000 tons of gravel each twenty-four hours. When the works are in full operation they will use about 80,000,000 gallons of water per day. The company is now running 1,500 inches per day. The various flumes are so arranged that they can clean up without stopping the work of mining. The main flumes are paved with stone, the branches with wooden blocks. The grade of the flumes is, as a general thing, 6 inches to each box of 12 feet, although some of them are upon a grade

of 5 inches. The company have steadily prosecuted their work for the past three or four years, and when their subterranean works, now being carried on, are completed, no one can doubt that great results will be obtained in the way of dividends. This company's new ditch was finished and washing commenced September 15, 1870."

A prospecting shaft has been sunk to demonstrate the depth of the gravel and the pitch of the bed-rock, preparatory to a survey for a gigantic bed-rock tunnel. The shaft struck bed-rock at a depth of 208 feet, (November, 1870,) and shows a fair quality of blue gravel, 138 feet in thickness, and very rich, at the bottom.

Moore's Flat and vicinity.—Six miles further up the ridge are the thriving towns of Moore's Flat and Eureka South, with many smaller camps, in which mining is actively carried on all the year round, on account of the abundance of water, which rarely fails in these high regions. One company, at Moore's Flat, report $65,000 as the product of the season. The mining above this point is principally carried on in drifts under the lava crust, and the lead is lost in the heart of the Sierras. Between North Bloomfield (formerly known as Humbug) and Moore's Flat, on the north bank of the South Yuba, is the mining camp of Relief Hill, where six companies are engaged in hydraulic mining. From this point can be seen the extensive auriferous deposit between the South Yuba and Bear River, on which are situated the towns of Alpha, Omega, and Washington. The whole northern slope of this "divide" has been worked for years, and is yet comparatively undeveloped. The general topography of these divides, and the situation of the detrital matter, would seem to indicate a general north and south sweep, which has been broken and eroded by the modern streams.

THE GRAVEL MINES OF NEVADA CITY AND GRASS VALLEY.

These localities are better known abroad for the productiveness of their quartz mines rather than for any notoriety acquired from their placers, which, however, were of unparalleled richness. At an early day attention was attracted to the richness of the gravel deposit lying under the ridge to the north of Nevada City. This ridge had been broken away in two places to a depth of one or two hundred feet, leaving a sugar-loaf-shaped mound between, and at this point drifts, then called "cayote holes," were run to develop the channel. Many of these claims have been abandoned, and at present the only extensive operations are carried on by Marcellus and Maltman, under and on the Sugar-loaf referred to.

This deposit of gravel was discovered in the spring of 1852, directly north of what was called in early days the old "Coyote Hill," the bed-rock in the channel being some 25 feet lower than that of "Cayote Hill." Its general course is due north, running through the main ridge, and terminating at Selby Flat, a distance of about 3,160 feet. Different companies located ground, claiming from 100 to 500 or 700 feet on the channel, and, with few exceptions, were largely rewarded for their exertions, some working with windlasses, whims, and steam-engines, sinking shafts or inclines, running tunnels from the shafts, and drifting the richest of the bottom gravel, using timbers usually 4½ feet in length, and leaving in and near the channel a strata of gravel overhead from 25 to 30 feet in depth, to the lower strata of pipe-clay which overlies the gravel deposit, though gravel and sand in alternate layers are found almost reaching the surface. The channel itself, or the lead, as it is called here, varies from 80 to 150 feet in width, but good pay is found the entire width of the deposit, averaging about 1,000 feet wide from east to west side.

The present claims of Marcellus and Maltman are very extensive, they having bought out nearly all their neighbors. In 1855 they commenced a tunnel for the purpose of hydraulic washing, which was completed in 1859, at a cost of $30,000. The grade of this tunnel being used up, they decided to run another a distance of 2,400 feet, which is 40 feet lower than the former, and will enable them to work all their ground. This new tunnel is now two-thirds completed, and, when finished, the total cost will not be far from $35,000.

The improved style of working this mine has demonstrated, during the past two seasons, that it can be worked for 50 per cent. of the gross yield; whereas, in former seasons, when worked by hydraulic washing on a small scale, the profits were not more than 10 per cent. of the gross yield.

I am indebted to W. M. Maltman, esq., of Nevada City, for the following statement of the yield of the gravel companies on this ridge. It is taken from the books of the companies:

Eversall & Co., (discovered)	$120,000
Johnson & Co.	30,000
Henry, Craddock & Co	75,000
Mountain Summit Company	125,000
Pacific Company	120,000
Live Oak Company	500,000
Young America Company	100,000
Bourbon Company	50,000
United States Company	60,000
Nebraska Company	550,000
Nevada Company	100,000
Keystone Company	90,000

The above claims were all drifted.

The amounts of gold by hydraulic washing on this gravel deposit are:

French Company	$40,000
White & Co	30,000
Stewart & Co.	48,000
O. M. Tomlinson	125,000
Marcellus & Maltman	257,000
As nearly as ever can be ascertained—Total	2,420,000

Three miles northwest of Nevada City the Cement Hill Tunnel and Fluming Company, a San Francisco incorporation, are fitting up for active operations next season. The grounds of this company have been noted for their immense yield. In 1853–'54 the sum of $240,000 was taken from an area of ground embracing less than two acres of surface.

Within a few miles of Nevada City there are large tracts of gravel which will pay by systematic and economical management, and the next two years will witness the revival of many enterprises which could not be carried on under the old system of working these deposits.

Grass Valley, situated in a basin surrounded by hills two or three hundred feet in height, in which are found the quartz ledges which have given this locality a world-wide fame, was noted in early times for its rich placers. These diggings were the results of two causes—the decomposition of the surface quartz and the dispersion of an ancient channel which debouched on the basin near the northern limits of the present town. This channel had a general course from northeast to southwest, and was probably a tributary to the ancient water-course system, as its dimensions are insignificant compared to those already described—its width from rim to rim rarely exceeding 150 feet, though it is covered by

overlying gravel, which overlaps its rims for a considerable distance on each side. The slide or breakage on the slopes of Alta Hill attracted attention at a very early period, and a tunnel was run in the hill, which resulted in the development of the rich ground of the Alta Company. These claims yielded large returns for a year, and were then abandoned.

The Hope Gravel Company.—In the early part of 1866, the Hope Gravel Company was incorporated in San Francisco, with a capital stock of $60,000, divided into 3,000 shares, and 6,000 feet of ground, located on Alta Hill, was purchased; the greater part of this, however, was supposed to be worked out. A systematic exploration was commenced, which continued without any encouraging discoveries for nearly four years, when the present brilliant prospects were struck. During this period forty assessments were levied, aggregating $98,250. Hoisting works were erected; shafts sunk, abandoned, and commenced again in more favorable locations; pumps and engines were replaced, until the present powerful and complete machinery was obtained, when perseverance and energy met with its reward in the striking of a channel at a point where its existence had for years been unsuspected. In sinking the various shafts of the company, the following strata were found: Red loam, 30 or 40 feet; volcanic ashes, about 100 feet; gravel, 4 or 6 feet; pipe clay, 60 feet; gravel, 1 to 3 feet; bed-rock—slate. The present working shaft of the company was sunk to a depth of 240 feet from the surface, where it struck the rim of the "South Channel," which had been worked out by the Alta Company and Rock Tunnel Company. The main drift was run north, through the old workings, but prospecting failed to discover the continuation of the Alta Hill channel. In this direction a sandy deposit was found, and exploration ceased until Mr. Brower, the present superintendent, took charge of the mine. Acting on the theory that the sand was a bar or island of the old river, he ran through it 150 feet, and was rewarded by striking the "North Channel," a distance of 350 feet from the shaft, which proved to be virgin ground. Drifts were run east and west, on the line of the channel, which proved to be from 80 to 90 feet wide, carrying gravel equal to any taken from the Alta Company's ground. These drifts demonstrated that the water-flow of this north channel was in an opposite direction to that of the south channel; the inference is that the old river took an abrupt bend, forming a horseshoe, and left a point of sand between the old workings and the present discovery. The shaft was sunk to a sufficient depth for drainage—the water from the mine flowing in a "sump" or well at the bottom of the shaft, whence it is lifted to the surface by two 10-inch pumps, and carried to a reservoir, from which it is conveyed to the sluice-boxes for washing the gravel. The loose gravel is run through a sluice consisting of sixteen boxes, of 12 feet each in length, with a grade of 8 inches to the box. It is then allowed to slack, and is run through a second time, with nearly as good results as the first. The hard cemented gravel and the quartz boulders, which are numerous in this claim, will require crushing. For this purpose an 8-stamp mill has been erected and attached to the shaft of the pumping-engine. This engine is of 40 horse-power, and will be used solely for the battery and pumps, as the hoisting apparatus is run by an independent engine of 20 horse-power. A contract has been let for cleaning out the old tunnels, which will drain the mine to some extent, and increase the available power of the machinery by relieving it of the duty of lifting large quantities of water. Twenty-five men are on the pay-roll, working ten-hour shifts; this force can be increased as the drifts on the channel are carried forward. Since the discovery of the north channel, the yield

per week has been from sixty to one hundred ounces of gold from the sluices, besides a large amount of gravel retained for crushing.

The success of the Hope Company has stimulated active operations along the line of this deposit, and many promising locations have been made recently, among which may be named the Altona, also a San Francisco company, which is opening ground between Alta Hill and Grass Valley, adjoining the Hope Company. To the north and west several companies, penetrating the deposit by tunnels, are taking out pay gravel. Webster & Co. are carrying on extensive operations in this direction, and have struck gravel from 2 feet to 6 feet in thickness which prospects very rich. The lower end of this ancient stream is being sought between the Grass Valley basin and Bear River. Extensive exploration is also being carried to the eastward, in the vicinity of Rough and Ready, and present appearances indicate a largely increased gold product from gravel mining.

BETWEEN GREENHORN CREEK AND BEAR RIVER.

The Great Blue Lead is the distinctive appellation of one of the largest ancient streams of California, which is found in the counties of Sierra, Nevada, and Placer. The name has been generally adopted on account of certain peculiarities of the lower strata of gravel of this channel, among which the distinguishing features are the color and hardness. The Blue Lead has had its greatest developments between Greenhorn Creek and Bear River, where are located the towns of Hunt's Hill, (called Gouge-eye in early times,) Red Dog, You Bet, and Little York. The peculiar nomenclature of these towns gives the traveler an unfavorable impression of the intelligence of the early miners. Such an opinion, however, is erroneous, for it must be remembered that when these places acquired their present names they were mere camps, without any prospects of growing into towns, and the names were given from some accidental local event or peculiarity to a temporary camp, which subsequently acquired sufficient importance to have a post office and express office, which had the effect of perpetuating the name, to the great disgust of the present residents.

The auriferous deposit has a general north and south course until it reaches You Bet, where it turns to the east. Its width is between half a mile and a mile, and the depth of the deposit varies from 100 to 300 feet—perhaps more at some places. The range is intersected by deep ravines and gulches emptying in Greenhorn Creek or Bear River, which in some places have been filled with tailings to such an extent as to render further hydraulic operations impossible until they are removed.

Cement mining.—The principal interest of this region is hydraulic and cement mining. The cement mining has been carried on by tunnels run to strike the channel, which has been followed and "breasted out" where practicable. The excessive hardness of the cement makes its extraction by this means expensive, and the proceeds of a fortunate season have often been expended the next in efforts to find the lead, which is frequently lost in consequence of the winding of the channel. The channel, although carrying gold almost invariably, is very much "spotted," and the large returns of some of the companies have been taken from a very limited area of bed-rock.

In July, 1867, there were, between Quaker Hill and Little York, nineteen mills, with one hundred and sixty-four stamps, erected at an aggregate cost of $100,000, for crushing cement, of which eighty stamps were then running regularly. (Report for 1869, page 31.) In October, 1870,

but one of these mills, that of Goodspeed & Co., at Hunt's Hill, was running regularly, and two or three others at intervals. Hydraulic operations are also suspended at all these points, except Little York, on account of the scarcity of water this season, which has been remarkable for its dryness, but it is probable that next year this branch of mining will be more extensively engaged in, at points where outlet is practicable, than for many years past. The owners of the cement claims formerly worked by mills are fitting up hydraulic apparatus for washing off the dirt down to the cemented gravel, and will not resume crushing until this top dirt is run off, when they can pursue this business free from the disadvantages and expense of underground workings. The hydraulic dirt is rich enough to pay well at present rates of water, (10 to 12½ cents per inch,) with the improved machinery now in use, and it is an absolute certainty that the bottom will pay largely when it can be mined and crushed without the expenses incident to underground operations. Taking the aggregate results of channel-mining, by means of tunnels and drifts, and crushing by stamps, on this range, we should find that it has not been a profitable business, considering the amount of capital invested, although some of the claims near You Bet have at seasons yielded almost fabulous returns.

Hydraulic mining.—At Red Dog, operations are necessarily suspended for want of an outlet. At You Bet, Williams & Co., Brown & Co., Neece & West, and the owners of the Hydelauff ground, (all having mills on this ground,) are preparing for hydraulic operations in 1871. At Quaker Hill, Messrs. A. A. Sargent and N. B. Jacobs own extensive hydraulic ground, which is worked with all the improved appliances. These gentlemen have suspended crushing at their mill, (the Green Mountain,) finding it unprofitable. Chalk Bluff, on the east side of the range, has been noted for the large quantities of silicified wood found in its washings at a depth of 150 to 200 feet; specimens of this may be found in all the mineral cabinets of California, and many of those in the Eastern States. In May, 1866, S. N. Stranahan & Co. located an extensive claim on Chalk Mountain ridge, commencing near You Bet, and following up the center of the ridge ten miles, having an average width of one mile. They have expended about $45,000 on this ground—the greater part of which was disbursed in perfecting the title. No work has been done on this claim for the past year, but operations will be resumed in the spring of 1871 at four different points. A section of this claim, from openings at various localities, shows the following strata: Lava, overlaid with a few feet of soil, 200 feet; volcanic ashes and débris, 200 feet; pipe-clay, 150 feet; white gravel, 200 feet; blue gravel, 10 to 50 feet; bed-rock, hard slate. The overlying lava appears only high up on the ridge, and does not come down as far as the towns named. The country in the vicinity of the head-waters of Greenhorn and Deer Creeks contains immense deposits of gravel, which have not been systematically worked for want of capital.

The towns on this range have greatly changed in appearance since 1867. Red Dog and You Bet have been destroyed by fire. The first-named town will not be rebuilt, former residents having removed to You Bet, less than a mile distant. Little York, then a decaying town, now presents a lively and prosperous appearance, the effects of the consolidation of most of the ground in a large company.*

* Since the above was written an extensive purchase of ground and water-ditches, comprising the valuable property of Neece & West, and Edward Williams, located between You Bet and Red Dog, has been made by a London mining company, and incorporated under the name of the Birdseye Creek Mining Company.

River sluicing.—The future of the region under consideration will depend to a great degree on finding an outlet for its vast quantity of hydraulic dirt. This can be obtained in some places by bed-rock tunnels; but at other points these are impracticable, and effectual outlet can only be had by emptying the streams and gulches of their vast accumulation of tailings. As an example of the extent of these accumulations, we will take Bear River. This stream has been filled to a depth of nearly 80 feet in the center, and its former banks so far covered that tall pine trees, formerly far above the stream, have been gradually engulfed, season after season, until now only the top branches appear above the current. It is believed that these tailings contain enough gold and quicksilver to pay a handsome profit for their removal, if an outlet could be found. A few years since a San Francisco company laid a flume in the bed of Greenhorn Creek, commencing at a point where a natural fall existed, with the intention of washing out the tailings, but an unusal flood of water broke up the boxes the first season, and the enterprise was not resumed, although pronounced feasible and profitable by all the miners of this vicinity. Mr. Uren, of Dutch Flat, a civil engineer and surveyor, has made a reconnaissance of the country between Bear River and the North Fork of the American River, and states that a tunnel could be run through the divide between these streams which would not exceed in length one and a half miles. As the American River runs through a gorge several hundred feet lower than Bear River, this tunnel would empty Bear River and its tributaries and open millions of cubic yards of hydraulic ground now without outlet, which otherwise can never yield up its wealth. The quantity of tailings in Bear River and its confluent gulches alone, above the mouth of the supposed tunnel, estimating, on an average width of 300 feet, a depth of 75 feet, and a length of ten miles, would be 44,000,000 cubic yards. We know that in early times a large proportion of the gold and quicksilver was lost; perhaps 20 per cent. would be too low an estimate of such losses. Of late years the proportion of gold and quicksilver carried off in the tailings has been smaller; the amount could be approximated by careful calculations of the results of the cleaning up of the last system of undercurrents and tail sluices of the claims emptying into this river, and by some experiments at favorable points. Let us suppose, however, that the general average of the tailings will reach 2½ cents per cubic yard, we have an aggregate of $1,100,000, to save which we must construct a tunnel of say 8,000 feet, lay it in flume, and place it in condition for running off the tailings. With the present facilities for running tunnels, by means of compressed air, diamond drills, and giant powder, we should not estimate the expense per lineal foot at over $10 or $12—the rock being an easily worked slate—which would give an aggregate of $100,000. Allow $50,000 for putting in flume and incidental expenses, and we have a total cost of $150,000. Now, if 50 per cent. of the gross amount estimated to be in the river can be saved, we have a result of $550,000, less the expense of cleaning up and original cost of tunnel. The contents of these tailings have been estimated by Mr. Uren and others at much higher figures than above. After the tailings were run off, the tunnel would be valuable property as a tail-sluice outlet for many square miles of hydraulic ground. We have made the calculation out of curiosity, but think this is one of the profitable mining enterprises of the future.

The Little York Mining and Water Company.—This is the most extensive mining operation between Greenhorn and Bear River. The company was formed two years since, and has purchased and consolidated

mining ground covering an area of about 240 acres, one-half of which is located at Little York, and the balance at Liberty Hill and Christmas Hill, a few miles distant. In addition to the ground thus acquired, they have purchased the ditches and water right of Thomas Gardner and Patterson and Maguire, three ditches with an aggregate length of forty-five miles, and having sufficient capacity to supply 3,000 inches of water. The width of the Blue Lead, which underlies all the ground at Little York, is from 300 to 500 feet, but the auriferous deposit has a surface width of about one mile. The average height of the banks from bed-rock to surface is 160 or 180 feet, of which from 20 to 40 feet is hard cement. The company have two mills for crushing cement, but this treatment has been abandoned on account of the superior facilities enjoyed here for the construction of a system of dumps, which serve to effectually break up and disintegrate the hardest cement, these claims having outlet both on Bear River and Steep Hollow, with at least 600 feet of fall to either stream. They have nearly 10,000 feet of flume, 4 to 6 feet wide, and nearly four miles of iron pipe for conveying water from their ditches to the ground. The company are running but a few hundred inches, but will run 2,500 inches next season with the newly-invented hydraulic nozzles, when they expect to take out from $12,000 to $15,000 per month. The past season has yielded $7,000 to $10,000 per month. Water is sold here at 9 cents per inch, being cheaper than at any other locality in the State.*

The Hydraulic Mines of Dutch Flat and Gold Run.—The districts of Dutch Flat and Gold Run, both centers of rich hydraulic districts, are situated on the ridge dividing the waters of Bear River and the North Fork of the American River, and are both on the line of the Central Pacific Railroad, which follows this ridge to the main Sierras. The hydraulic diggings here are very extensive, and have been profitable to an unusual degree. The channel, which presents all the characteristics of the Blue Lead, is evidently the same ancient water-course developed at You Bet, which, turning to the east at Little York, passes under this ridge, through Dutch Flat and Gold Run districts, and debouches on the North Fork of the American River at Indiana Hill.

Dutch Flat district, comprising an area of mining ground of about 640 acres, is situated at the confluence of two ancient channels—the Blue Lead, and a channel which comes down the divide between Bear River and the North Fork of the American, from east to west. Placer mining was commenced at Dutch Flat in 1849, and hydraulic operations on a large scale in 1856 and 1857. The main lead has a width of 2,000 feet, and an average depth of 240 feet. Bed-rock has been reached at only one point—the shaft of James Teaff—and has nowhere been stripped. The bottom is known to be very rich, but is excessively hard, and cannot be profitably worked without a bed-rock tunnel. Two small mills of eight stamps each were erected in 1868 and inclines sunk on the rim-rock. Rich gravel was struck, but the expense of pumping and hoisting on such a small scale caused the abandonment of the enterprise. Hydraulic mining has been carried on here only on a small scale for two or three years past, the surface having been washed off to a depth of 100 feet or more, below which the gravel was found so hard as to require the use of large blasts. The present outlet will admit of another bench being washed off on most of the claims, which will pay well with the use of large streams of water through the improved nozzles.

Most of the ground at Dutch Flat is owned by individuals or com-

* This claim has passed under the control of a company of English capitalists.

panies in tracts varying from twenty to fifty acres. The most extensive mining property in the State, owned by one individual, is that of James Teaff. Besides his large area of ground, he owns a tail-sluice over one mile in length, six feet in width, and two in depth, one-half of which is in tunnel. This tail-sluice cost $55,000, and has been exceedingly profitable during seasons of active mining operations. Three large ditches furnish water for the Dutch Flat and Gold Run districts, the principal ditch being that of the South Yuba Company. These ditches have an aggregate capacity of 7,000 inches. Water is sold at 12½ cents per inch.

Gold Run district.—This district commences at the line of the Central Pacific Railroad and runs southerly two miles to Indiana Hill, below which the North Fork of the American River has broken through the alluvial deposit. The area of the hydraulic ground embraces 1,000 to 1,200 acres, and is owned and worked by about forty companies. The auriferous deposit here is of great depth, and the dirt much softer than at Dutch Flat; the consequence is that an immense amount of dirt is run off every season, and the natural outlet of the upper part of the district is fast choking up with tailings. Operations must soon be suspended here unless a bed-rock tunnel is run. Surveys have been made for such a tunnel, which will be 4,000 feet in length, and when completed will insure the continuance of hydraulic mining for many years. A prospecting shaft sunk to bed-rock about the center of the district, and the operations of the cement mill at its lower end, have satisfactorily demonstrated the great extent and richness of the blue cement on the bottom. No blasting is required here, as the dirt and gravel can be run off down to the blue cement with heavy streams of water.

Hydraulic operations on a large scale were not commenced here until 1862. From that period to 1865 the gold dust was taken to Dutch Flat and other places for sale. I am indebted to Mr. Frank Moore, of Moore & Miner, bankers at Gold Run, for the following statement of the amounts of gold dust bought by them from 1865 to 1870:

1865	$139,877 02
1866	237,908 62
1867	309,812 65
1868	259,188 05
1869	189,918 73
1870, (up to October 1st)	183,384 86
	1,320,089 93
During this period there was produced from claims, in which M. & M. had an interest, not included in the above statement	62,814 60
	1,382,904 53
Add fifty per cent. for gold dust produced in the district and sold elsewhere	691,452 26
Total	2,074,356 79

It will thus be seen that in six years this small district has produced over two millions of dollars. These large returns are to be attributed to the quantity of ground run off, by reason of the soft character of the dirt, rather than to its richness.

The most extensive claims in the district are those of Brogan & Co., at Indiana Hill, a brief description of which will convey an idea of the character of mining operations here. This company have a large area of ground, exposing a face of hydraulic dirt 240 feet in height, all of which, except some thin layers of pipe-clay and sand, is pay-dirt, with no indication of the proximity of the lower strata of blue cement. The

bank exhibits alternate layers of hydraulic dirt, gravel, sand, and pipe-clay, with an occasional layer of lignite, a few inches in thickness, which is found at a depth of from 200 to 240 feet. They run 1,000 inches of water per twenty-four hours, through two Hoskin nozzles, 4½ inches diameter each, under a pressure of 290 feet. The Hoskin nozzle is a local invention, and does not materially differ in its operations from those already described. Formerly 500 inches were run, in four streams of 2½ inches in diameter each, requiring a man to each stream. Through these streams water could be effectively thrown more than 100 feet; but the improved nozzles will do execution at 200 feet, dispense with the labor of two men, insure safety of human life in case of the banks suddenly caving—which may be always anticipated here from the height of the bank and the softness of the dirt—and will run off 100 per cent. more dirt than the same amount of water run through 2½-inch nozzles. This immense body of water is conducted from the ditch to the distributor in iron pipes 500 feet in length, having a diameter of 27 inches at the discharge-box. The pressure is so great that the strongest distributors, made of cast iron ½ inch thick, are required, and these sometimes burst. Messrs. Brogan & Co. will open this ground next season through their new sluice-tunnel, 1,200 feet in length. This tunnel, which is 40 feet above bed-rock at its starting point, and probably 100 at its terminus—the ground getting deeper as it runs back in the hill—will be continued 700 feet farther until it reaches the back line of their ground.

Indiana Hill Cement Mining Company.—The only cement mining carried on here is by the Indiana Hill and Mining Company at the lower end of the district. This company commenced operations several years since at a point where the ancient channel bed-rock is broken off and denuded by the deep gorge through which runs the North Fork of the American River. This company have ground 1,600 feet in length by about 400 feet in width. The width of the channel at this point is undefined, and extends for several hundred feet on either side of this company's ground; or perhaps there is a confluence of two channels here. The claim is worked through a tunnel 200 feet in length, 20 feet in width, and 10 feet in height, from which drifts have been run and extensive breastings made. Although 10 feet in height of pay has been taken out, there is milling cement left overhead. The tunnel is run on the bed-rock, and drains the ground as it progresses. The car-loads of cement are run out on a tramway a distance of 600 feet from the mouth of the tunnel to the mill of the company. This is an eight-stamp mill, run by a "hurdy-gurdy" wheel 8 feet in diameter, using 75 inches of water under a pressure of 75 feet, and has a crushing capacity of thirty to thirty-six tons per day, according to the hardness of the cement. The cost of the milling and mining will probably not exceed $1 50 per ton. The claim is worked very skillfully and economically. The occurrence of large boulders and the hardness of the cement renders expensive timbering unnecessary. Very little water has been met with, and that runs off by the tunnel. The officers decline at present giving a statement of their receipts and expenses. Twenty men are employed, and rumor says the company is clearing $100 per day over expenses.

It is estimated that $20,000,000 in gold have been taken out from the vicinity of Forest Hill alone, and that an abundance of water would revive the placer-mining interest in that and adjacent districts, and render claims profitable that are now worthless. The principal mining towns are Iowa Hill, Damascus, Todd's Valley, Michigan Bluff, and Forest Hill. Michigan Bluff is on the Middle Fork of the American, and possesses a large body of hydraulic ground, with an average depth of over

200 feet. The principal interest of Forest Hill is in cement mining. The cement is mined by tunnels, and drifts run under the lava crust, and crushed by mills. This branch of mining has not been actively prosecuted for the past year, for want of capital, although there is much unworked ground. Four mills are idle; one working regularly, and one at intervals; and six or eight hydraulic claims worked on a small scale. The product of Forest Hill district for 1870 will slightly exceed $200,000. At Bath, near Forest Hill, there is a claim which is an exception to the general rule of the "pay" dirt lying nearest the bed-rock. In this claim the pay-lead is many feet above the bed-rock—in some places 150 feet—and is confined in a very thin streak from six to sixteen inches in thickness, very hard, and of a rusty appearance. This lead runs almost on a level into the hill for several thousand feet, and has been worked with regular and profitable results for three thousand feet.

Dr. Henry De Groot, of the San Francisco Commercial Herald, who visited this region in the fall of 1870, speaks of its resources as follows: "There are many claims still unopened, affording opportunities for the profitable investment of millions of dollars on this divide; and yet the whole is an industrial waste, notwithstanding the San Francisco capitalist can, any day, after having taken his breakfast, ride with the utmost comfort and at small cost into the very heart of this district, in time to take his supper. In making this brief and pleasant journey he will pass over such treasures of gold lying just a little beneath his feet, as he would never see upon the bank counters or in the capacious vaults of the Mint. It fills one with amazement, after examining a stretch of country like that extending from Todd's Valley to Last Chance, that it should be so neglected, with the evidence of its opulence almost in sight. Ten thousand men could find remunerative employment here for years, without exhausting these deposits, which could be so easily reached, and could hardly fail to prove immensely profitable."

Between the North and Middle Forks of the American.—The country between the North and Middle Forks of the American River is an elevated mountainous region, no part of which is less than 3,500 feet above the level of the sea. The whole country is cut up by ravines and tremendous cañons of great depth and grandeur, and presents features of natural scenery rarely equaled, even in California. This scenery has been graphically described by Bayard Taylor in "At Home and Abroad." This region contains probably one hundred square miles of mining ground, the greater part of which is covered by lava and volcanic matter, and is opened and mined through tunnels. Mining operations have not been extensively carried on since 1866, when the following amounts of gold dust were shipped through the express offices of the principal towns. The figures are from the books of W. Van Vector, assessor for that year:

Forest Hill	$367,000 00
Todd's Valley	148,482 00
Michigan Bluff	400,000 00
Iowa Hill	163,633 92
Total	1,079,115 92

Add to this twenty per cent. for dust carried off to other localities, and we have a product of $1,414,939 10.

The country between these rivers is but scantily supplied with water, most of the districts being limited to a supply of 1,000 inches, and even

this cannot be depended upon for more than a few months in the year. Should Colonel Von Schmidt's magnificent enterprise of tapping Lake Tahoe, and bringing its waters through this region to the foot-hills, and thence to San Francisco, be completed, we may look for a renewal of mining operations here which will revive the flush times of '49-'50.

The object of the Lake Tahoe Water Company is to supply with water a large portion of the central part of the State, comprising the best mineral and agricultural lands of California, besides supplying some of the principal towns. An act of Congress has granted all the privileges required for right of way, and the company, under the management of Colonel A. W. Von Schmidt, as chief engineer, is now proceeding energetically with the work. Lake Tahoe is situated among the summits of the Sierra Nevadas, in the easterly part of Placer County, at an elevation of 6,000 feet above sea level, and has an almost unlimited depth—soundings having been made with a 1,500-foot line without touching bottom. Its greatest length is twenty-eight miles, and the area of the lake is estimated at two hundred and fifty square miles. One foot in depth of this surface would give a daily supply for the year of 13,748,252 gallons. If required, the lake can be raised six feet by a small dam at its outlet, and can be drawn six feet below its present surface—which would give 12 feet of water from the entire surface of the lake, or 164,899,024 gallons per day. But should the company take all the water that discharges itself from the outlet now running down the Truckee River, and supplying the lumber region of Truckee and the mills at Reno, Nevada, there still would be more water in the river below than can possibly be used, for the reason that so many large streams enter below the point of the dam. The dam has already been constructed at the outlet of Tahoe into the Truckee—for a distance of four miles. In the spring the tunnel will be commenced, running through the Sierras in a westerly direction for a distance of three miles. At this point the water will be turned into the North Fork of the American River, and will follow the bed of the river for a distance of twenty-five miles. The water will be diverted from the river on the Auburn side, and carried to that town by a canal. From Auburn it is proposed to bring the water to San Francisco, Sacramento, Vallejo, Oakland and other localities.

Iowa Hill and vicinity.—The town of Iowa Hill is on the summit of the mountain range which forms the east bank of the North Fork of the American River. The interest here is hydraulic washing and cement mining. The hydraulic mining can only be carried on for a brief season in each year, as the four ditches which supply the place, none of which are over six miles in length, will not furnish, in the aggregate, over 1,000 inches of water in the best season—less than is run in one set of claims at Gold Run on the opposite side of the river. Two large cement mills are running—the Columbia, twenty stamps, (steam,) at Monona Flat, and the Morning Star, twenty stamps, (steam,) near Wisconsin Hill. The latter claim has 5,000 feet on what appears to be a blue lead channel, and has been a profitable enterprise for many years—the owners, however, are somewhat reticent as to their operations, and we can furnish no statistics. Many other milling enterprises have been abandoned, as it is believed most of the ground can be more profitably worked by the hydraulic process when water in sufficient quantities shall be brought in.

The gold product for the past three years, based on purchases and shipments by J. W. Chinn, agent of Wells, Fargo & Co., has been as follows:

1868	$185,000
1869	162,000
1870, (June to October—a very dry season)	69,550
Balance of year 1870—estimated	10,000
	426,550
Add 20 per cent. for dust sold elsewhere	85,310
Total	511,860

We have a total product here, allowing for overestimates, of at least $500,000, and comparing these returns with the limited quantity of dirt washed off, on account of the scarcity of water, I am inclined to the belief that the ground here pays a very high rate per cubic yard—probably over 20 cents. The miners here look with anxiety to the completion of the Lake Tahoe Water Company's works, which will give them a steady and unfailing supply of water—the amount of ground here being almost unlimited in extent.

As the ancient river bed known as the Blue Lead is abruptly broken off by the deep cañon of the North Fork, at Indiana Hill, opposite Monona Flat, and distant not more than two miles in an air line, we might expect to find its continuation on this side of the river. Such is not the case, however; and if it exists, it has not been sufficiently developed to prove its identity. Extensive hydraulic operations at Iowa Hill and Wisconsin Hill seem to favor the theory of a wide expanse of water with rapid currents, depositing beds of gravel in basins and depressions of the bed rock, rather than to an ancient channel system so plainly indicated on the west side of the river. It is, however, highly probable that the Blue Lead channel of Indiana Hill will be found, as we learn that experienced miners are prospecting for it higher up the river.

The Great Cañon of the North Fork.—This cañon is ten or twelve miles long, with a depth of from 1,800 feet to 2,200 feet, rarely exceeding 2,000 feet in width, from summit to summit of its inclosing mountain walls. The mountain sides, rising abruptly, and the river winding in serpentine folds, gives the observer with every turn a fresh view, which seems to excel in wildness and sublimity that which he has been gazing on in awe and astonishment. Bayard Taylor thus describes the view of this cañon at its westerly extremity, as presented from the Illinoistown and Iowa Hill trail: "As we approached the North Fork of the American, a far grander chasm than any we had yet encountered yawned before us; the earth fell sheer away to an unknown depth (for the bottom was invisible,) while a mighty mountain wall, blue with the heated haze of noonday, rose beyond, leaning against the sky. Far to the east a vision of still deeper gorges, overhung by Alpine peaks, glimmered through the motionless air."

River mining is still prosecuted on the banks and bars of this stream, principally by Chinese, of whom there are several camps in the great cañon, between Jehovah Gap and Cape Horn. The breakage of the great ancient river, whose bed was nearly 2,000 feet above the present water level of the American River, has scattered its contents throughout this cañon, where they have lodged against projecting points of the banks and become in the course of time as hardly compacted and cemented as in its original bed. Inclines and drifts are run in these gravel banks, and operations conducted until the rising of the river in winter drives out the miners. At Green Valley, a few miles above the cañon, nuggets of washed gold of great size—some as large as pigeon-eggs—have been found in abundance in a shaly blue clay, which is described

as presenting the appearance of having been the former bed of the American River—running parallel to it and not more than 50 feet above its present bed. These "strikes" are of almost annual occurrence in this locality.

SIERRA COUNTY.

The limited time at my disposal and the lateness of the season did not admit of a visit to this county. For all the information embodied in the following letter, I am indebted to Mr. E. Spaulding, for many years county surveyor of that county, who, in the prosecution of his official duties, has gained an extensive knowledge of the mining resources of Sierra county:

"Deep placer mining in this county is principally confined to the Blue Lead, which extends through the county parallel to the main range of the Sierra, and at right angles to the present streams. This body of blue gravel is usually covered several hundred feet deep with volcanic débris, and is about half a mile wide and fifty feet deep. The portion that pays for working is usually about three or four hundred feet wide, and from one to three feet deep, lying on and near the bed-rock. Very little of this deposit has been worked by hydraulic process; the principal method has been to work through tunnels, shafts, and inclines. When raised to the surface, the gold is easily washed out of the gravel through sluice-boxes. A few miners are receiving small returns for working portions of the deposit that were once considered worthless, and for working over again portions that paid very large returns for working before. There is about two miles of the deposit between Forest City and Rock Creek that has not been worked, owing to a want of drainage at the Rock Creek end and at the Forest City end, which is owned in small tracts, too small to justify the individual companies in opening it. At present the North Fork Mining Company, an incorporated company, whose place of business is at Forest City, own over a mile of mining ground, and have a tunnel in progress that will strike the deposit at about 3,000 feet from the place of beginning. This is one of the most promising mines in Sierra County. The Rock Creek end of the deposit is owned by the Adellia Company—not working. At Fir Cap there are two companies receiving good returns for their work. At Morristown and Cold Cañon the deposit is worked out. At the towns of Howland Flat, Gibsonville, and Whiskey, the deposit is wider, and pays less than at points where it is narrow. The width of the deposit and the regular yield gives a permanence to the work being done at these towns, and at present rates of progress it will probably take ten years to work out the deposit. North of the North Yuba River, and parallel to the Blue Lead, and about three miles below or west of it, are located the towns of Eureka, St. Louis, and Port Wine. The deposits at these towns have been worked by hydraulic process, and with the exception of about one claim at each town, that will yield good returns for two or three years to come, the ground is worked out. There is a deposit lying between Middle and North Yuba Rivers, and parallel to the Blue Lead, and about eight miles above or east of it, marked by mining camps, among which are the towns of American Hill and Nebraska; this deposit may be considered exhausted. The towns of Pike City, Indian Hill, Brandy City, and Scales district, and intervening camps, mark the course of a deposit that extends through the county parallel to the Blue Lead, and about twelve miles below or west of it. This deposit has been principally worked by hydraulic process."

I am under obligations to Mr. L. E. Crane, superintendent of the

Alleghany City Gold Mining Company, Alleghany City, Sierra County, for the following:

Smith's Flat, the development and subsequent exhaustion of which as a placer deposit led naturally to hydraulic mining first, and next to the conception and prosecution of the idea of following the gravel into the mountain by means of tunnels, lies to the south of Downieville, Sierra County, about eight miles.

The place was named in honor of the discoverer of the diggings, who, following a ravine up the mountain side from Kanaka Creek, and taking a fortune out as he went, reached a bench formation situated halfway from creek to summit, and opened on the southerly edge of one of the richest placer deposits ever worked in California. This was in 1850–'51; and a prosperous mining camp attested the value of the ground during the period of its working. No vestige of the camp remains, but the town of Alleghany—with its outlying suburb, Cumberland—has since grown into and maintained its existence in the close vicinity.

The first tunnel which entered the mountain was commenced early in 1853, and was named the "Packard," from Dr. Packard, one of its projectors and owners; it still retains its name, and is yet used to work through, the gravel paying fair wages to work again, and an occasional bit of undisturbed ground being discovered and worked very profitably.

The Packard tunnel paid from the start. No assessment, beyond the light contributions necessary to a commencement, were called for, and the owners received large individual fortunes from dividends. This was owing to the fact that no "rim rock" was encountered, but the tunnel was in the gravel of the famous Blue Lead from the time of erecting the first set of timbers. Whether the absence of rim rock may be accepted as conclusive evidence that the Blue Lead debouched from the mountain at this point, winding southerly through Chip's Flat, Minnesota, Moore's Flat, etc., is by no means certain, but no other probable outlet for it has been noticed.

Following the Packard, and stimulated by prospects that were almost certainties, came the "Alleghany," "Pacific," "Knickerbocker," "Bay State," "New York," "Red Star," "Excelsior," "Masonic," "Jenny Lind," "Hooking Bull," "Buckeye," "Blue Tunnel," "Clipper," and other companies—the famous "Live Yankee" penetrating the same mountain, but from the westerly instead of easterly side. The histories of these companies were uniformly the same; the tunnels penetrated the rim rock, the gravel on the front of the lead was worked at great profit, and when the main Blue Lead was reached, it was necessary to sink an incline and effect drainage by means of pumping. This method of working was expensive, difficult, and necessarily far from thorough or exhaustive; yet the yield of gold was enormous, and the mines were considered very valuable by their owners.

From the claims of the "Fremont," "Knickerbocker," and "Masonic," were taken respectively the sums of $40,000, $90,000, and $60,000 in the space of a month, and it was not difficult for any of the claims to procure credit for almost unlimited supplies and money. That every owner connected with either of the tunnels was not greatly enriched, was owing more to the fact that they all became entangled in expensive litigation regarding boundaries, and that much of what might have been profit went to pay lawyers and witnesses, than to any other cause. It is one of the unwritten jokes of the vicinity that, on the occasion of one of these trials of title at Downieville, an honest miner gave testimony descriptive of the situation and course of the Blue Lead. He

traced it as far north as that town, and when the attorney asked him, "Where does it go from here?" he replied, "I think it comes right into the court-house here and don't go no further!"

Not one of these companies has worked out the ground reached by their tunnels. Various causes combined to induce cessations of work; mining excitements in distant localities attracted owners away; tunnels became first dilapidated, then ruined, and in 1858-'59 the end of exciting rush and competition had been reached, and many of the claims were lying untouched. In several of them, however, work was still done by men who had succeeded to proprietorship, and it was proved that even ground which had once been worked would pay in these days of cheaper supplies and lower wages. In October, 1870, the owners of the "New York" claim discovered a very rich deposit of gravel, which had been passed under by the original tunnel when on its course to the channel. The weekly yield from this deposit where it was first opened was 104 ounces ($1,846) from the gravel got out by "four men at the pick." Its extent is not yet fully determined, but enough has been prospected to denote that there is a very large body of it. In 1868 several of the claims, with portions of others, were purchased, and are now being developed and worked by an incorporated company known as the "Alleghany Consolidated Gold Mining Company." A tunnel was projected that should be low enough to afford sure drainage for all the ground it was designed to work, and, indeed, low enough to drain the Blue Lead at any point in the mountain. It was commenced near the starting-point of the Blue Tunnel, the course of which it followed for 900 feet, at which point it deviated to the east sufficiently to leave 20 feet between them. In December, 1870, this tunnel was near 2,000 feet into the mountain, and was close in the vicinity of a large body of unworked gravel of the Blue Lead. It is a key to the entire mountain, and there are strong probabilities that it will soon develop into a rich paying claim.

CHAPTER II.

NEVADA.

THE COMSTOCK MINES.

The aggregate yield of the mines on the Comstock lode was considerably greater for the year 1870 than for 1869, closely approximating, indeed, the production of 1868; and, during the latter part of the year, the amount disbursed in dividends was notably large. This is partly due to the fact that a few companies extracted large quantities of ores, the costs upon which were kept low by the large scale of operations. Thus the Chollar-Potosi produced the enormous sum of $2,627,938, of which $658,000 was paid out in dividends, and the Hale and Norcross, producing $1,708,281, paid out $512,000 in dividends. The advantages of the Virginia and Truckee Railroad have been very evident in the cheapening of freights and timber. The explorations of the Bullion, Imperial, and Ophir have been barren of results up to the end of the year; on the other hand, the deep workings of the Gould and Curry, Yellow Jacket, and Crown Point, have furnished much reason for encouragement as to the future. Of especial significance is the discovery in the latter mine, at the close of the year, and at the deepest level, I believe, ever reached upon the Comstock lode, of a new, large, and valuable body of ore, which is apparently disconnected with any other hitherto worked. The San Francisco Weekly Stock Circular quotes from a letter dated January 15, concerning this discovery, as follows:

The winze in the soft ledge at cross-cut No. 1, on the 1,100 level, is down on the line of the incline, following the west clay, 44 feet. The face of it is in clear bright-looking quartz, showing spots here and there. The entire face on the raise of the east body, from cross-cut No. 1, 1,100 level, is in ore that will mill $50 per ton. The character of the ore is black sulphurets and chlorides mixed through it. The incline raise is four feet high, and it is safe to calculate that the ore extends two feet beyond, making an ore body six feet in width. The mine has never been prospected in this section from the 1,100 level up to the 300, and while this ore body may and doubtless will vary in size and quality, there is no doubt but that it will prove an extensive body of ore. The improvement in the quality and extent of the raise occurred at a point 30 feet up from track floor.

I learn that subsequent developments still further enhanced the importance and extent of this discovery, and I regard it as a striking demonstration of the continuance of ore-bearing character on this vein in depth. Especial significance is attached to the fact that the level in which this body has been struck is but three or four hundred feet above that of the proposed Sutro tunnel—the 1,100 feet level of the Crown Point being 1,563 feet below the croppings of the Gould & Curry. (According to the Virginia Enterprise, the Sutro tunnel level would coincide with the 1,300 foot level of the Crown Point; but this is probably erroneous, since Mr. Carlyle's survey makes the tunnel intersect the Savage claim 1,922 feet below the floor of the Savage works, or about 1,960 feet below the croppings of the Gould & Curry. The rise in drifting 6,900 feet, from Savage through Crown Point, would not be more than 6 feet.) Since much doubt has been thrown upon the enterprise of Mr. Sutro, on account of the alleged barrenness of the Comstock in depth, it is fortunate that this development has occurred in time to encourage the prosecution of the much-needed deep tunnel.

This tunnel is now in process of construction, and has been carried in about 1,900 feet, through various alternations of rock, and several veins, none of which, so far as I am aware, have been prospected. A good deal of water has been met with, which may be considered, so far as it goes, a favorable indication of the existence of fissure-veins in the neighborhood, though, at the inconsiderable depth thus far attained, the significance of its occurrence is not important. My opinion as to the necessity and value of this tunnel remains unchanged, except so far as it has been strengthened by recent developments upon the Comstock. As a means of exploring that vein to a depth heretofore unattained in metal-mining, it will be indispensable. Some of the shafts in the Comstock are now approaching the level of the tunnel-survey; but the expense and difficulty of going deeper will be well nigh insurmountable, without an adit as a new basis of operations. The effect of a tunnel, adequate for drainage, transportation, and ventilation, is to create a new, artificial surface, with the added advantage of a hydraulic power, measured by the quantity of water and the height of its fall above the tunnel level. A few months ago, suggestions of this nature were met with the reply that the Comstock shafts were not finding ore in depth, and that nobody was likely to desire to go much deeper in barren ground. In successive reports I have uniformly regarded this barren ground as a zone, beyond which ore bodies would again be found; and this opinion is now so far confirmed that I presume no one will now discourage further explorations in depth, up to the limits of mechanical practicability.

As it is understood that Congress will order an examination of this subject by a commission of military and mining engineers, the further discussion of it upon the present occasion is unnecessary. The report of that commission would be rendered, probably, in the winter of 1871. Meanwhile, I trust that the tunnel may be pushed forward. This is one of the few localities in the country where such a work is really required.

The prospects of the Comstock mines are certainly better than they were a year ago. Prices in all departments have never been so reasonable as now; and the general economy of management has never been better. The reserves in the Chollar, Hale & Norcross, Savage, and Yellow Jacket are understood to be still large, and those of the two former are in their lower chambers. The Washoe stocks have shown, in a general advance in price, the effect of this encouraged aspect of affairs.

Among the casualties of the year were two, which claim particular attention, as indicating special sources of danger in the mines upon this lode. The first was a cave between the 800 and 900 foot levels of the Yellow Jacket mine, caused by a flake of ore and vein matter falling from the hanging wall. Three sets of timbers in length, two in height, and two in width, were crushed, and four miners were buried under the mass. The following extract from a local paper vividly describes the vain attempt to rescue the only victim who was not immediately killed:

As soon as the cave occurred in the Yellow Jacket mine, several brave men from the floors below hurried up the ladders to the rescue, knowing full well that some of their comrades must be there, and in need of immediate help. The danger was great, for the timbers were still cracking and pieces of ore falling; yet they ventured close to the ruins, and the light of their candles revealed one man jammed among the debris, and still alive. This man was Hanson. They could get near enough to touch him, and he was able to freely converse with them. A heavy timber across his hips and others about his legs held him fast. Only one or two men could work in the narrow space at a time, and very cautiously, by reason of danger from the still moving mass. They worked with saw and axe, and for over two hours the poor fellow talked with them as they worked. He called for water, which they gave him three or four times. He was

in great pain, but cool and sensible to the last. One of his comrades bade him keep up good spirits, and they would have him out shortly. "Ah, boys," said he, "good spirits is getting played out." Then, at times, in his agony, he would beg them to end his sufferings by splitting his head with the axe. At last, his voice could be heard no longer, and on examination he was found to be dead.

The system of timbering employed on the Comstock lode is very expensive; and it is hardly practicable to renew the timbers, so large is the amount of material required. The extent of the open spaces left by stoping, the very steep dip of the lode, and especially of the ore-bodies in it which are removed, and the impracticability in most cases of filling up with "deads," or leaving sufficient pillars for support, necessitates a vast complex of heavy morticed timbering. At the same time, the carelessness of early workings has left large quantities of low-grade ore in the upper levels, so that the companies for several years have extracted ore from old workings. This unfortunate combination of circumstances makes it necessary to keep open portions of the mines which might otherwise be abandoned. The great expense of mining in this district is due, next to the cost of prospecting for ore-bodies, to the necessity of extensive timbering; and the same cause has led to several accidents, the principal of which was the disastrous fire in the Kentuck and Crown Point, mentioned in a former report.

Another accident, occurring at the Hale and Norcross mine on the 24th of August, was more directly the result, in my opinion, of reprehensible carelessness. The Gold Hill News describes it as follows:

Thomas Stanton and David Ryan, together with John Cochran and Matt. Sullivan, were engaged in sinking the shaft deeper. An empty car was being lowered on the cage; when near the top of the shaft the heavy bolt connecting the brake-lever with the friction-band around the brake-wheel broke square off. The consequence was that cage and car, weighing nearly a ton, immediately descended with frightful velocity to the bottom of the shaft, which is 1,200 feet deep, the heavy wire cable following it just as fast as the swiftly revolving reel would allow. Indeed, the engineers ran out of the way, expecting every instant to see the reel and brake-wheel fly into fragments. They say a perfect stream of sparks flew from the friction-wheel and brake-strap nearly to the ceiling. Fortunately, however, the flying end of the cable, as it left the reel and dashed down the shaft, did very little damage. The cage and car, in their descent, passed through two strong platforms of heavy timbers a foot thick; one of them about 45 feet from the bottom, and the other only 10 or 12 feet above the heads of the men, passing through both as though shot from a cannon. Stanton and Ryan were standing erect, or nearly so; therefore they were both crushed down to instant death, the bodies of both being considerably mutilated and broken. Cochran was bent over, working, and was knocked prostrate, with his legs under the cage, but the other unfortunates receiving the full force of the falling weight saved him, and he escaped with comparatively light injuries. We were present at noon to-day while Drs. Webber and Hall were making a surgical examination of him at his cabin. They found the head of the right thigh bone fractured at the hip joint. A pick, or something of the sort, had also evidently been driven several inches into the fleshy part of the thigh at the under side, but this wound was not considered serious. Sullivan, the fourth man, was working beneath another compartment of the shaft, a few feet distant; therefore was lucky enough to escape entirely unhurt. The cable fell, coiled among the debris of the broken platforms, upon the car and cage; therefore it was quite a job to extricate the dead bodies. The bolt broken was not defective. It was two inches in diameter and showed no flaw, but simply a square break of good solid iron. This accident of course developes the now evident fact that a two-inch iron bolt was not strong enough, yet no one could hardly be blamed for mismanagement; it was a purely accidental circumstance, and one of those unforeseen calamities continually occurring in our mines. Two strong brakes instead of one might be used, and thus the recurrence of a similar accident prevented in the future. Engineering invention certainly can contrive some sort of safeguard to apply in such emergencies. The cage was of the safety pattern, but owing to the tension kept upon the cable the safety clutches were not free to act, as they would have infallibly and effectually done in case of the cable breaking. We append this last remark by reason of having heard several persons state this was not a safety cage. It was, and a very good one at that—so strong that it was but little injured by its fall.

It seems to me that no "engineering invention" is required to prevent

such a catastrophe. This case is but one of many warnings which the Comstock mines have furnished against the practice of lowering cages by the brakes instead of unwinding with the engine. I remember that for several years it was the rule in the Gould & Curry mine to lower with the engine; and during that time not a single accident occurred in the shaft. Lowering by the brakes is letting the cage, with the continually increasing weight of cable, fall down the shaft, regulating its descent merely by the brakes upon the friction-wheel, which are controlled by a long lever, reaching to the station of the engineer. The inequality of the pressure of a man's hand upon such a brake-gearing is made very unpleasantly evident to a person descending in the cage by a surging alternation of velocity, as the momentum of the fall is now allowed to accumulate and now suddenly checked. In lowering cages which do not carry human passengers, less care is exercised in regulating the velocity, and the resulting strains upon every part of the cable and machinery are of the most dangerous character. It is true that a simple device might be employed to stop the revolution of the bobbin when the brakes fail to act; but it would be far better to avoid dropping the cages in this way, and, by lowering steadily with the engine, to secure a uniform instead of an alternately accelerated and retarded rate of descent.

STATISTICS OF THE MINES.

The following statistics are offered in continuation of those presented in former reports:

Report of the Belcher for the year ending February 1, 1871.

The receipts for the past year were $278,541, including $204,253 from bullion and $72,095 from assessments. The expenses were $277,017, the leading items being $123,214 for crushing ores and $85,388 for labor, leaving $624 cash on hand. During the year the amount of ore crushed was 11,353 tons, yielding an average of $17 99, at a cost of $10 85 per ton.

Report of the Gould & Curry for the year ending November 30, 1870.

RECEIPTS.

From 23,499 tons ore worked at custom mill	$661,013
Premium, sale of slimes, etc.	6,891
Sale of 268 tons of ore	1,677
Assessment No. 7, $15 per share	72,000
Assessment No. 8, $12½ per share	60,000
Sundry mill material sold	11,357
Returned freights Virginia and Truckee Railroad	5,068
Miscellaneous	1,086
Total	819,092

DISBURSEMENTS.

Cash indebtedness November 30, 1869	$29,934
Dividends to stockholders	48,000
Labor at mine	229,399
Timber and lumber	59,978
Wood	33,175
Iron, hardware, charcoal	16,387
Machinery and foundery work	6,676
Candles	4,940
Sundries on account of mine	14,531
Mill account	4,338

Reducing 25,194 tons ore, custom mill	$302,063
Taxes	6,637
Exchange	2,434
General expenses	22,211
Interest	2,665
Miscellaneous items	8,882
Total	792,240
Cash on hand November 30, 1870	26,852
Total	819,092

The assets of the company aggregate $203,614, against which there are liabilities amounting to only $2,629. The superintendent reports 24,305 tons of ore taken from the mine during the year, averaging $28 16 per ton.

The president's report gives the following comparisons of the operations of the mine for the past three years:

Year.	Ore.	Yield.	Mining.	Milling.
	Tons.		*Cost.*	*Cost.*
1870	24,305	$28 16	$6 82	$12 85
1869	15,879	26 30	7 29	13 08
1868	12,153	18 14	3 73	12 62

Report of the Hale & Norcross for the year ending March 1, 1870.

RECEIPTS.

Cash on hand February 28, 1869	$137 74
Bullion	1,321,018 77
On account assessment No. 34	18,840 00
Premium on bullion	9,434 86
Sundries	6,631 57
Total	1,356,062 94

DISBURSEMENTS.

Assessment No. 34 rescinded	$20,800 00
Mine labor	267,084 50
Mine material	114,499 57
Ore reduction	567,808 20
Salary	10,630 05
Virginia and Truckee Railroad	25,000 00
Dividend account	192,000 00
Sundry accounts	39,847 55
Cash on hand February 28, 1870	118,392 47
Total	1,356,062 94
Cash assets	240,182 45
Property assets	214,646 85
Total	454,829 30
Liabilities	32,000 00
Excess of assets over liabilities	422,829 30

Comparative statement of cost of mining and milling, together with yield of ore, for 1868 *and* 1869.

	1868.	1869.
Cost of wood per cord	$14 40	$13 09
Cost of timber per M	28 40	28 29
Cost of milling ore per ton	13 11	12 49½
Yield of ore per ton	23 90	27 13⅛
Paid labor per ton of ore extracted	9 01$\frac{6}{10}$	5 13$\frac{8}{10}$

Report of the Yellow Jacket for the year ending July 1, 1870.

Product of mine, $1,779,229; receipts from assessments, $528,000; total receipts, $2,307,227. Indebtedness July 1, 1869, $305,605; expenditure during the year, $1,722,725; balance on hand July 1, 1870, $278,897, as follows: on deposit, $119,609; due on railroad account, $129,056; supplies on hand and paid for, $30,332; total, $278,897; and to balance debit side, add up $2,307,227.

The following is the detailed statement:

The receipts for the year have been as follows:

Bullion product	$1,702,726
Ore sold	10,254
Morgan mill	65,929
Assessment No. 12, levied July 19	240,000
Assessment No. 13, levied November 26	120,000
Assessment No. 14, levied March 16	168,000
Advertising balance	318
Total	2,307,227

The disbursements amounted to $2,028,331. The principal items are the following:

Indebtedness as per last report	$305,606
Labor at the mine	340,500
Mine supplies	51,748
Improvements in hoisting works	14,485
Legal expenses	3,852
Revenue stamps, advertising, etc	5,278
Candles and oils	12,112
Wood	58,103
Timber	85,748
Crushing ores—outside mills	769,342
Crushing ores—company's mills	272,849
Assay, discount on bars, and Federal tax	30,988
Interest	30,491
Salary of officers	16,200
Working tailings—company's mills	10,179
Miscellaneous	20,880
Total	2,028,331

The assets of the company aggregate $285,102, as follows:

Cash in Bank of California	$119,609
Mine supplies	16,691
Mill supplies	15,747
Due on assessments Nos. 1 to 14	1,135
Due on $160,000 advanced to V. & T. R. Co	129,057
Sundry open accounts	2,863
Total assets	285,102
Liabilities	6,206
Assets above liabilities	278,896

The above figures represent the condition of the company at the close of the fiscal year ending June 30, 1870. No dividends were disbursed. The apparent profit for the year was $584,502, of which $305,606 was used to liquidate an indebtedness at the beginning of the year, while the remainder represented the surplus assets at the close, of which $119,600 was in cash.

Report of the Kentuck for the year ending November 1, 1870.

18,103 tons of ore, yielding $371,198, or an average of $20 50 per ton, were produced.

RECEIPTS.

From bullion	$371, 198 24
Assessment No. 3	10, 000 00
Lumber contract paid last year	11, 250 00
Other items	485 88
Total	392, 934 12
Cash on hand November 1, 1869	79, 880 54
	472, 814 66

DISBURSEMENTS.

Dividends to stockholders	$70, 000 00
Crushing ores	220, 970 48
Labor	102, 127 50
Timber	21, 179 97
Hoisting ore	8, 594 70
Oil, candles, and other supplies	7, 115 57
Mine and office expenses	12, 238 53
Gold Hill expenses	5, 968 98
Branch railroad to Kentuck dump	5, 135 79
Assaying	4, 026 23
Miscellaneous items	9, 312 11
Total	436, 669 86
Cash on hand November 1, 1870	6, 144, 80
	472, 814 66

Report of the Imperial Empire for the year ending May 31, 1870.

RECEIPTS.

Cash on hand May 31, 1869	$7, 680 16
Bullion	176, 689 53
Assessments	141, 740 63
Gold Hill and Rock Point mills	3, 674 10
Property sales	15, 000 00
Bills payable	22, 000 00
Imperial Empire shaft	2, 406 89
Sundries	10, 451 67
Total	379, 642 98

DISBURSEMENTS.

Gold Hill mill	$98, 989 23
Rock Point mill	3, 295 58
Alta mine	96, 756 03
Holmes mine	5, 178 55
Imperial Empire shaft	83, 945 63
Virginia and Truckee Railroad Company	27, 000 00
New drifts	11, 352 00

General expense	$13,674 01
Expenses in San Francisco	8,470 35
Legal expenses	6,035 05
Bills receivable	15,000 00
Sundries	9,765 55
Cash on hand May 31, 1870	181 00
	379,642 98

The cost of reducing 12,020 tons of ore, (including hauling,) amounted to $7 96 per ton, with supplies on hand. The cost of extracting 11,925 tons of ore from the old shaft amounted to $7 20 per ton, including shaft repairs, sinking, etc. Since the company went into operation, the expenses for milling and mining purposes, including new machinery and improvements, aggregate $4,113,290, and the dividends paid stockholders foot up $1,067,500. In the same time the receipts from ores and sundries sold for account of mines and mills were $5,303,517, and from assessments $291,740. At the date of this report the total indebtedness of this company was $22,000, against which $18,259 37 was due on assessment No. 7, and $15,000 on bills receivable.

Report of the Chollar-Potosi for the year ending May 31, 1870.

RECEIPTS.

Cash on hand as per last statement	$168,991 35
Bullion account	1,479,128 59
Ore sold	3,530 97
Insurance upon property destroyed	37,000 00
Virginia and Truckee Railroad	1,219 47
Sundries	804 44
Due on open accounts	593 00
	1,691,267 64

EXPENDITURES.

Dividend account	$420,443 00
Labor	234,605 35
Working ore	760,174 00
Timber and lumber	55,308 35
Firewood	9,230 71
Taxes	6,661 74
New shaft	16,191 98
Freight	7,249 40
Assaying	3,166 93
Materials	8,211 82
Hardware	6,983 66
Candles	5,842 00
Legal expenses	4,369 97
Water account	2,356 75
General expenses	7,642 82
Superintendent Requa	3,262 07
Sundry accounts	11,314 14
Cash on hand	128,352 96
	1,691,267 64

The following has been the yield of the mine for the year: Blue Wing section, 26,044 tons; New Tunnel, 12,000; Grass Valley, 6,212; Belvidere, 8,000; Cooffing, 4,380; Total 56,636 tons. Amount reduced, 59,354 tons; average yield per ton, $24 86; cost of milling per ton, $12 81; cost of labor and materials, $3 99; total cost per ton extracted, including rebuilding and repairs at new shaft, $5 52; total expenses

per ton, $18 33; showing a net yield of $6 53. The following table shows the number of tons of ore worked and bullion yield for each month of the fiscal year ending May 31, 1870:

1869-'70.	Tons worked.	Bullion.
June	6,807	$175,671
July	6,412	163,650
August	6,593	149,398
September	5,517	116,667
October	5,286	108,970
November	3,578	87,580
December	3,201	76,184
January	4,495	115,263
February	4,058	91,545
March	4,549	113,189
April	4,313	130,361
May	4,545	146,983
Totals	59,354	1,475,461

Report of the Sierra Nevada for the year ending January 1, 1871.

RECEIPTS.

Bullion	$220,287 05
Other sources	9,939 77
	230,226 82

DISBURSEMENTS.

Indebtedness per last statement	$16,077 05
Dividends	37,500 00
Mill account	47,132 10
Mine account	45,847 91
Wood account	32,099 04
Cedar Hill Float Rock title	11,662 95
Crushing, outside mills	4,700 00
Incidentals	14,646 86
Cash on hand	20,560 91
	230,226 82

The above exhibit is the most favorable ever made by this company, and its future prospects are as flattering as have been the results for the past year. Prudent management has at last been able to make this mine profitable.

Report of the Gold Hill Quartz Mining and Milling Company for the year ending January 1, 1871.

The receipts for the year amounted to $87,192, of which $17,287 was from bullion produced; $27,206 from the operations of the mill; and $15,000 from two assessments, levied in May and September. The disbursements embraced $42,210 for milling, $6,868 for mining, $9,083 for improvements, and $5,661 for general expenses. The assets consist of book accounts to the amount of $12,939, against which there are liabilities amounting to $9,560, showing a surplus of $3,379.

Report of the Overman for the year ending July 1, 1870.

RECEIPTS.

Balance on hand July, 1869	$8,032 33
Bullion	482,433 72

Wood ranch account	$20,079 90
Ore sold	10,139 00
Bills payable	8,390 66
Miscellaneous receipts	1,927 47
	531,003 08

EXPENDITURES.

Crushing account	$285,074 84
Labor	115,869 00
Lumber	34,560 92
Assessment No. 14	14,290 00
Wood ranch expenses	10,108 41
Lambert lease	12,500 00
Supplies, &c	9,363 05
Wood account	6,908 93
Assaying	4,952 72
Legal expenses	3,192 18
Salary account	4,813 26
Tools, hardware, etc	3,020 77
Sundry accounts	13,777 64
Cash on hand July 1, 1870	13,471 36
	531,003 08

There were extracted 40,021 tons, and reduced 30,885 tons, yielding $15 02 per ton. The capital stock has been changed from $1,600,000, divided into 3,200 shares of $500 each, to $1,280,000, divided into 12,800 shares of $100 each.

Report of the Savage for the year ending July 11, 1870.

RECEIPTS.

Cash on hand July, 1869	$47,395 29
Bullion	281,570 27
Ore sold	9,495 00
Tailings sold	4,576 60
Assessments	280,000 00
Miscellaneous receipts	2,397 87
	625 435 03

EXPENDITURES.

Labor and salaries	$231,396 12
Timber and lumber	32,751 21
Hardware, candles, etc	36,080 70
Wood and charcoal	50,510 65
Reduction of ores, etc	106,581 83
Paid to Truckee Railroad	75 000 00
Custom mills	30,524 67
Miscellaneous	53,144 60
Cash on hand July 11, 1870	9,445 25
	625,435 03

Statement of product of bullion, dividends, and assessments of the various mines on and near the Comstock lode during the first three months of 1870, *together with the aggregates of the same period during the four preceding years.*

Companies.	Bullion product.	Dividends.	Assessments.
Belcher	$99,474		
Bullion			$10,000
Caledonia	13,796		
Chollar-Potosi	319,997	$84,000	
Consolidated Virginia			23,200
Crown Point	49,172		90,000
Dancy			8,000
Empire Mill and Mining Company			12,000
Gold Hill Quartz Mill and Mining Company	3,802		
Gould & Curry	101,841		72,000
Hale & Norcross	440,594	96,000	
Imperial			40,000
Julia			6,000
Justice			36,000
Kentuck	92,297	40,000	
Lady Bryan			12,000
Ophir			84,000
Overman	178,842		
Savage	55,625		160,000
Segregated Belcher			12,800
Sierra Nevada	38,925		
Yellow Jacket	375,000		168,000
In 1870	1,769,365	220,000	734,000
In 1869	2,040,885	588,000	156,200
In 1868	1,764,046	310,000	557,500
In 1867	2,765,531	850,000	230,780
In 1866	2,291,893	90,000	474,600

Bullion product, dividends, and assessments of the leading mines on the Comstock lode during the second quarter of 1870, together with the aggregates for the same period for four preceding years.

Companies.	Bullion product.	Dividends.	Assessments.
American			$34,800
Belcher	$95,062		41,600
Bullion			25,000
Caledonia			
Chollar-Potosi	492,893	$84,000	
Confidence			15,600
Consul Virginia			
Crown Point	46,385		
Dancy			
Empire Mill and Mining Company			12,000
Gold Hill Quartz Mill and Mining Company	4,246		10,000
Gould & Curry	183,794		
Hale & Norcross	478,524	168,000	
Imperial			40,000
Julia			7,500
Justice			
Kentuck	53,895		
Lady Bryan			
Occidental			60,000
Ophir			84,000
Overman	142,211		
Savage	6,300		120,000
Segregated Belcher	29,575		6,400
Sierra Nevada	46,499		
Yellow Jacket	480,000		
Total in 1870	2,059,384	252,000	456,900
Total in 1869	1,914,816	257,500	311,500
Total in 1868	2,535,442	597,750	380,600
Total in 1867	4,299,122	1,218,200	209,900
Total in 1866	2,634,815	436,000	212,800

Returns to the county assessor of Storey County for the quarter ending June 30, 1870.

Companies.	Tons.	Average per ton.	Total product.
Chollar	13,328	$36 70	$489,670
Chollar, (Lynch)	3,005	18 80	56,614
Gould & Curry	6,048	22 00	133,118
Gould & Curry, (roasted)	48	644 60	30,941
Hale & Norcross	17,785	26 90	478,438
Savage	203¼	30 98	6,304
Savage, (sold)	474¾	20 00	9,495
Yellow Jacket	20,316	23 14	470,125
Yellow Jacket, (sold)	3,170	1 00	3,170
Belcher	6,139	15 48	95,061
Occidental	1,100	8 00	
Crown Point	4,055	12 88	46,410
Kentuck	3,390	15 89	53,364
Overman	9,464	14 73	141,480
Empire	500	12 30	4,637
Imperial	2,500	12 22	30,550
Sacramento	372	5 00	1,858
Sierra Nevada	5,288	9 28	48,074

Returns to the county assessor of Storey County for the quarter ending September 30, 1870.

Companies.	Tons.	Average per ton.	Total product.
Hale & Norcross	16,366	$29 08	$475,924
Chollar	17,689	43 83	775,308
Chollar, Lynch	3,480	20 02	69,669
Yellow Jacket	10,245	19 74	202,244
Savage	2,599	24 46	63,587
Savage, (sold)	792	5 00	3,961
Gould & Curry	5,387	31 30	168,629
Gould & Curry, (roasted)	100	352 85	35,298
Sierra Nevada	4,614	12 02	55,476
Crown Point	3,723	14 36	53,459
Kentuck	1,780	9 80	17,548
Ophir			2,014
Savage, (by Union Mill Company)	792	19 30	15,292
Overman*			
Imperial*			

* Not handed in in time for this report.

Returns to the county assessor of Storey County for the quarter ending December 31, 1870.

Companies.	Tons.	Average per ton.	Total product.
Crown Point	4,050	$19 12	$77,462
Chollar	24,656	41 90	1,034,911
Chollar, M. Lynch	3,120	19 08	59,527
Savage	8,206	18 02	152,857
Gould & Curry	5,612	29 63	166,283
Gould & Curry, (bousted)	17	205 62	3,495
Hale & Norcross	15,185	20 30	308,258
Overman	6,386	19 08	126,634
Overman, (account sold)	888	1 00	888
Yellow Jacket	9,245	36 83	340,573
Sierra Nevada	4,163	15 09	62,820
Belcher	70		
Succor	2,300	15 45	35,535
Imperial	5,500	10 77	59,397
Empire, by C. C. Stevenson	1,100	17 27	18,499

Bullion product of leading mines on the Comstock Lode for 1870.

[Compiled by Richard Wheeler, esq., of San Francisco Stock Report.]

Companies.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Belcher	$34, 106	$50, 789	$14, 628	$31, 698	$27, 316	$36, 048							$194, 585
Crown Point		22, 046	33, 440	19, 680		26, 730	$20, 188	$16, 484	$23, 215	$20, 394	$26, 673	$32, 357	241, 207
Chollar	115, 263	91, 545	113, 189	130, 361	146, 984	215, 548	261, 277	249, 553	264, 551	275, 716	258, 297	505, 654	2, 627, 938
Gould & Curry	18, 239	33, 384	50, 213	48, 725	94, 045	41, 027	36, 586	75, 041	109, 022	65, 252	60, 099	44, 553	676, 186
Gold Hill Quartz	3, 808				3, 682	560	482		2, 153	1, 825	2, 076	2, 533	17, 119
Hale & Norcross	188, 334	145, 203	107, 057	125, 849	164, 830	187, 845	200, 863	149, 328	125, 969	116, 766	115, 540	80, 697	1, 708, 281
Imperial	13, 675	12, 601	11, 932	12, 975	10, 104	7, 478	10, 390	11, 192	18, 632	26, 357	18, 028	14, 895	168, 259
Kentuck	31, 207	29, 301	31, 790	21, 226	18, 929	13, 740	9, 466	8, 083					163, 742
Overman	49, 299	57, 613	72, 090		51, 000	18, 700	19, 200	16, 600	21, 800	37, 400	48, 400	41, 900	433, 912
Savage	25, 650	7, 035	23, 030	6, 300				32, 400	32, 650	45, 330	47, 325	71, 400	291, 120
Sierra Nevada	12, 327	12, 092	15, 472	15 667	15, 798	16, 342	12, 820	28, 055	23, 939	21, 002	24, 879	24, 981	223, 374
Segregated Belcher					29, 574	26, 170	10, 091			8, 140			73, 975
Yellow Jacket													*1, 500, 000
Total													8, 319, 698

* Information refused; estimated.

Dividends for 1870.

Chollar Potosi	$658,000
Sierra Nevada	37,500
Gould & Curry	48,000
Hale & Norcross	512,000
Yellow Jacket	144,000
Kentuck	40,000
Total	1,439,500

The census returns indicate nearly the same production as the tables of the companies. Thus, according to the latter, the bullion product for the year ending June 30, 1870, was $7,401,665; but for the year ending June 1, 1870, the aggregate production was reported by the assistant marshal as follows:

Ormsby County.—From the Santiago, Vivian, Yellow Jacket, Merrimac, Brunswick, and Mexican—6 mills	$1,939,205
Storey County.—From the Proctor, Jennings, Bassett, (2,) Parks and Bowie, Evans, Meredith, Nevada, Delano, Jane, Succor, Ramsdell, Papoose, Piute, Empire, Imperial, Pacific, Petaluma, Rhode Island, Gold Hill, Sunderland, Sapphire, Mariposa, Empire State, Hoosier State, Bay State, Boston, Johnson, and Sierra Nevada—29 mills	3,590,700
Lyon County.—From the Lykins, Pioneer, Sherman, Fair and Mackey, (2,) Briggs, Hill, (2,) Union Mill and Mining Company, (6,) Weston, Hobart, Shad, Overman, Gold Hill, Janin, Birdsall, and Winters—22 mills	1 411,120
Washoe County.—From the Auburn, Avery, and Dall—3 mills	578,130
Total	7,519,155
Or, deducting the Auburn, which is at Reno, and does not usually treat Comstock ore	160,000
	7,359,155

The Nevada Land and Mining Company, (limited,) (Auburn mill,) at Reno, pays the following prices for silver ores, which it will buy in any quantity:

For ores assaying per ton	$40	Per cent. of assay value	25
Do......do	50	Do......do	30
Do......do	60	Do......do	37½
Do......do	70	Do......do	40
Do......do	80	Do......do	43
Do......do	90	Do......do	48
Do......do	100	Do......do	50
Do......do	125	Do......do	56
Do......do	150	Do......do	60
Do......do	175	Do......do	63
Do......do	200	Do......do	65
Do......do	250	Do......do	68
Do......do	275	Do......do	70
Do......do	300	Do......do	72
Do......do	350	Do......do	74
Do......do	400	Do......do	77
Do......do	500	Do......do	78
Do......do	600	Do......do	79
Do......do	700	Do......do	81
Do......do	800	Do......do	82
Do......do	900	Do......do	83
Do......do	1,000	Do......do	84

Quotations of mining stocks commonly dealt in at the San Francisco Stock and Exchange Board.

[From San Francisco Weekly Stock Report of February 4, 1871.]

Name of company.	No. feet in mine.	Shares per foot.	Total number shares.	Incorporate value.	Bid per share.	Asked per share.	Last dividend per share.	Last assessment per share.	Delinquent.	Day of sale.
Alpha, (consolidated)	300	20	6,000	$250				July 13, —, $1 00	Aug. 13, 1870	Sept. 10, 1870
Amador	1,850	2	3,700	400	$302 50	$310 00	April 7, 1870, $10 00			
American	2,900	4	11,600	100				June 13, —, 3 00	July 13, —	Aug. 6, 1870
Belcher	1,040	10	10,400	100	9 75	9 87½		Dec. 2, 1870, 1 00	Jan. 1, 1871	Jan. 24, 1871
Bullion	2,500	1	2,500	400				Dec. 9, 1870, 3 00	Jan. 8, 1871	Feb. 2, 1871
Crown Point	600	20	12,000	250	32 00	32 25	Sept. 12, 1868, 5 00	Oct. 28, —, 3 50	Nov. 27, 1870	Dec. 2, 1870
Confidence	130	12	1,560	500				May 14, —, 10 00	June 14, 1870	July 8, 1870
Consolidated Virginia	1,160	10	11,600	500	5 00	5 25		Dec. 9, —, 1 50	Jan. 9, 1871	Feb. 1, 1871
Consolidated Chloride								Dec. 14, —, 1 00	Jan. 14, 1870	Feb. 24, 1870
Chollar-Potosi	2,800	10	28,000	100	74 00	75 00	Jan. 16, 1871, 5 00	Feb. 10, 1868, 5 00	Mar. 12, 1866	
Daney	2,000	4	8,000	100				Jan. 10, 1871, 1 50	Feb. 9, 1871	Mar. 4, 1871
Exchequer	400	20	8,000	60				Jan. 30, 1868, 3 00	Mar. 1, 1868	Mar. 25, 1868
Empire Mill and Mining Company	75	16	1,200	100			May 15, 1867, 7 00	Oct. 18, 1870, 4 00	Nov. 17, 1870	Dec. 13, 1870
Eureka	1,680		20,000	833	70 00	74 00	Jan. 7, 1871, 10 00			
Featherstone			1,400	300				June 14, 1870, 20	July 15, 1870	Aug. 11, 1870
Flowery								Nov. 12, 1869, 1 00	Dec. 11, 1869	Jan. 7, 1870
Gould & Curry	1,200	4	4,800	500	45 50	46 00	Oct. 10, 1870, 10 00	July 14, —, 12 50	Aug. 13, 1869	Sept. 8, 1869
Gold Hill Quartz Mill and Mining Company	13½		500	500			July 13, 1868, 7 50	Sept. 8, 1870, 1 00	Oct. 8, 1870	Oct. 31, 1870
Golden Chariot	750	13	10,000	100	79 50	81 50	Jan. 10, 1871, 4 00			
Hale & Norcross	400	20	8,000	100	102 00	103 00	Jan. 10, 1871, 5 00	Feb. 12, 1869, 5 00	Mar. 15, 1869	April 8, 1869
Hidden Treasure Consolidated	600	20	12,000					Mar. 28, —, 25	April 8, —	May 24, 1870
Ida Elmore				100	9 50	10 00		Jan. 31, 1871, 2 50	Mar. 3, 1871	Mar. 31, 1871
Imperial	184		4,000	500	6 00	7 00	June 10, 1868, 6 00	Feb. 1, 1871, 10 00	Mar. 4, 1871	Mar. 24, 1871
Julia	2,000	5	10,000	100				Oct. 14, 1870, 50	Nov. 13, 1870	Dec. 1, 1870
Justice and Independent			3,000	100				Mar. 21, 1870, 12 00	April 21, 1870	May 23, 1870
Kentuck	95		2,000		32 50	33 00	Mar. 10, 1870, 5 00	Jan. 17, 1871, 10 00	Feb. 17, 1871	Mar. 10, 1871
Mammoth	1,800	20	36,000	100	20	25		Jan. 31, 1871, 10	Mar. 3, 1871	Mar. 31, 1871
North Star			3,000	400			Jan. 10, 1871, 1 00			
Noonday								Jan. 19, 1871, 20	Feb. 19, 1871	Mar. 17, 1871
Oriental								Oct. 10, 1870, 20	Nov. 10, 1870	Nov. 30, 1870
Occidental			10,000	100				Dec. 21, 1870, 5 00	Jan. 21, 1871	Feb. 22, 1871
Original Hidden Treasure			21,333	100	3 00	3 25	June 10, 1870, 1 50	Jan. 31, 1871, 1 00	Mar. 3, 1871	Mar. 31, 1871
Ophir	1,400	12	16,800	300	3 25	3 50		Jan. 11, 1871, 2 00	Feb. 14, 1871	Mar. 9, 1871
Overman	1,200	10⅔	12,800	500	4 50	5 00		Dec. 8, 1870, 2 50	Jan. 7, 1870	Jan. 30, 1871
Rising Star	1,200	10	12,000	300				April 7, 1870, 50	May 8, 1870	June 4, 1870
Segregated Belcher	160	40	6,400	300				Jan. 14, 1871, 2 00	Feb. 14, 1871	Mar. 8, 1871
Savage	800	20	16,000	200	45 00	45 50	June 11, 1869, 3 00	May 3, 1870, 7 50	June 3, 1870	June 25, 1871
Sierra Nevada	3,000	5	15,000	200	14 50	15 00	Jan. 16, 1871, 1 00	Nov. 16, 1868, 12 50	Dec. 17, 1868	Jan. 5, 1869
Silver Vault								July 20, 1870, 5	Aug. 20, 1870	Sept. 17, 1870
Silver Wave	1,600	10½	20,000					April 21, 1870, 3 00	May 22, 1870	June 13, 1870
Yellow Jacket	1,200	20	24,000	100	41 00	41 25	Jan. 10, 1871, 2 00	Mar. 15, 1869, 7 00	Apr 16, 1870	May 19, 1870

Highest and lowest prices of mining stocks for 1870.

[From the San Francisco Stock Report.]

Name of company.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Alpha	$18 00	$11 00	$14 00	$10 00	$21 00	$10 00	$18 00	$12 00	$14 00	$10 00	$10 00	$5 00	$8 00	$6 00	$8 00	$5 00	$8 00	$3 00	$8 00	$6 00	$6 00	$5 00	$8 00	$5 00
Amador	320 00	310 00	337 00	310 00	370 00	350 00	370 00	192 00	232 00	195 00	225 00	195 00	230 00	210 00	220 00	182 00	240 00	217 00	250 00	240 00	247 00	240 00	245 00	245 00
Belcher	16 00	15 00	18 00	16 00	35 00	16 00	35 00	21 00	24 00	19 00	17 00	7 00	7 00	5 00	7 00	4 00	4 00	2 00	5 00	1 00	3 00	2 00	8 00	4 00
Bullion	10 00	10 00	10 00	4 00	7 00	7 00	7 00	4 00	4 00	4 00	4 00	4 00	6 00	4 00	6 00	6 00	6 00	6 00	5 00	5 00	5 00	5 00	5 00	5 00
Chollar-Potosi	20 00	18 00	21 00	18 00	32 00	22 00	33 00	24 00	29 00	27 00	30 00	25 00	37 00	31 00	47 00	38 00	61 00	46 00	75 00	49 00	83 00	70 00	91 00	68 00
Confidence	35 00	20 00	20 00	20 00	40 00	15 00	37 00	20 00	20 00	17 00	17 00	17 00	17 00	17 00	17 00	17 00	17 00	17 00	5 00	5 00	5 00	5 00	5 00	5 00
Crown Point	16 00	10 00	19 00	11 00	25 00	17 00	27 00	14 00	16 00	13 00	12 00	6 00	7 00	5 00	6 00	4 00	7 00	4 00	6 00	3 00	7 00	2 00	18 00	10 00
Daney	1 25	10	1 25	1 25	4 50	3 00	7 50	4 87½	6 50	4 75	6 00	2 00	2 00	1 75	2 00	2 00	3 00	3 00	4 00	2 00	4 50	2 50	7 75	4 00
Empire Mill	30 00	19 00	22 00	14 00	40 00	14 00	33 00	15 00	19 00	10 00	19 00	19 00	5 00	5 00	7 00	2 00	6 00	1 00	1 00	1 00	5 00	1 00	6 00	5 00
Exchequer	8 00	7 00	7 00	6 00	11 00	7 00	15 00	6 00	15 00	8 00	10 00	5 00	5 00	5 00	5 00	5 00	5 00	5 00	7 00	6 00	5 00	5 06	5 00	5 00
Gould & Curry	72 00	44 00	82 00	40 00	500 00	95 00	380 00	145 00	190 00	117 00	103 00	60 00	72 00	37 00	161 00	45 00	155 00	98 00	109 00	83 00	94 00	71 00	90 00	45 00
Hale & Norcross	163 00	145 00	164 00	126 00	146 00	127 00	145 00	124 00	147 00	128 00	132 00	87 00	93 00	83 00	93 00	84 00	121 00	83 00	117 00	106 00	118 00	101 00	121 00	102 00
Imperial	51 00	30 00	36 00	18 00	50 00	17 00	48 00	35 00	48 00	30 00	41 00	26 00	43 00	36 00	39 00	23 00	40 00	25 00	40 00	35 00	30 00	17 00	22 00	11 00
Kentuck	146 00	105 00	106 00	81 00	105 00	65 00	92 00	64 00	7 00	42 00	44 00	29 00	32 00	26 00	55 00	30 00	46 00	34 00	40 00	24 00	40 00	31 00	41 00	30 00
Occidental	17 00	12 00	13 00	9 00	19 00	11 00	16 00	9 00	13 00	5 00	10 00	8 00	9 00	5 00	11 00	3 00	11 00	5 00	7 00	25	5	5	50	50
Ophir	15 00	12 00	14 00	11 00	24 00	11 00	27 00	16 00	17 00	12 00	14 00	8 00	16 00	10 00	15 00	7 00	7 00	3 00	5 00	2 00	4 00	3 00	6 00	3 00
Overman	19 00	16 00	17 00	16 00	26 00	16 00	24 00	16 00	23 00	18 00	19 00	15 00	17 00	7 00	14 00	7 00	10 00	6 00	8 00	6 00	7 00	5 00	6 00	3 00
Savage	46 00	38 00	41 00	31 00	52 00	29 00	55 00	33 00	37 00	30 00	47 00	27 00	53 00	31 00	42 00	33 00	42 00	36 00	40 00	32 00	40 00	26 00	52 00	39 00
Segregated Belcher	8 00	6 00	7 00	5 00	8 00	5 00	12 00	6 00	8 00	4 00	4 00	1 00	5 00	3 00	3 00	1 00	4 00	1 00	3 00	2 00	2 00	1 00	3 00	1 00
Sierra Nevada	10 00	7 00	8 00	6 00	9 00	6 00	8 00	7 00	7 00	8 00	11 00	8 00	11 00	9 00	11 00	8 00	12 00	10 00	14 00	12 00	19 00	13 00	21 00	18 00
Yellow Jacket	55 00	43 00	54 00	43 00	52 00	41 00	55 00	41 00	48 00	42 00	50 00	38 00	40 00	25 00	36 00	28 00	29 00	24 00	38 00	25 00	37 00	30 00	48 00	35 00
Eureka			235 00	225 00			280 00	260 00	290 00	290 00	305 00	295 00			300 00	300 00							380 00	375 00
Oriental							1 62½	60	1 25	75	3 00	1 37½	5 50	4 50			1 25	1 25						
Union M. and M															15 00	15 00	19 50	9 00	7 00	7 00				
Maxwell																			7 00	7 00	7 00	7 00		
American																								
Consolida'd Virginia					17 00	10 00	14 00	10 00	13 50	11 00	10 00	8 50	9 00	1 00	9 50	6 00	5 00	4 00	4 00	3 00	6 00	5 00	6 75	3 00
Flowery																								
Gold Hill Quartz	35 00	34 00	22 00	15 00	30 00	15 00	30 00	16 00	15 00	2 00	22 00	50	23 00	23 20					13 00	2 50				
Julia	1 00	50			1 00	70	90	90	50	50			1 50	20	1 00	20	1 00	20	1 50	1 00	2 00	1 37½	6 00	2 00
Justice			3 00	3 00	3 00	80	1 00	1 00																
Succor																								
Ida Elmore					24 00	2 50	25 00	24 00							20 00	20 00	10 00	10 00	10 00	10 00	13 00	10 00	17 00	12 00
Mahogany																								
Rising Star																								
Meadow Valley					30 00	25 00	35 00	30 00	25 50	23 00	23 00	23 00	27 00	2 00	30 00	18 00	25 00	17 00	19 50	16 50	26 00	18 50	23 00	28 00
Eureka, consolidated																			19 00	9 00	22 50	19 37½	18 75	15 50
Jackson																								
Golden Chariot	14 00	10 00	18 00	12 50	18 50	13 00	16 00	13 00	15 50	14 00	15 00	10 00	21 50	14 00	25 00	20 00	30 50	22 50	50 00	30 00	70 00	54 50	3 50	50

Tabular statement of the number of assessments, number of feet in mine, number of shares, number of dividends, total amount of assessments and dividends, amounts of assessments and dividends per share of the leading mines in California, Nevada, and dealt in at the San Francisco Stock Board, being an extract from a tabular statement by R. Wheeler, editor of the San Francisco Stock Report.

Mr. Wheeler remarks in regard to these statistics:

The compiling of the following statistics may seem to the novice a light task, requiring neither time nor trouble, although the information that is given is the most valuable ever published since the mines that are upon the list of the San Francisco Stock and Exchange Board have assumed the importance that is to them now attached. The State of Nevada has proven herself in minerals to be one of the richest in the Union, and the speculation in her mines has built up a business in this city wherein profit is concerned that is equaled by none other. Her wealth was first made known by the capital drawn from San Francisco, and the greatest portion of the stock in her richest mines is owned by its residents, yet so great is the ignorance pertaining to them, that men claiming to be well informed upon the subject, unhesitatingly avow that far more money has been spent in developing her mines than what has been extracted from them, while the dividends would not come within 25 per cent. of the amount collected for assessments. Doubting the correctness of such assertions, I entered upon the undertaking of collating the aggregate amounts that have been disbursed in dividends and collected by assessments, by and upon the mines that are now dealt in daily in the San Francisco Stock Board. The figures which are below presented go to show that the dividends far exceed the assessments, and that the mines on the Comstock have returned a splendid interest upon the money that has been spent in developing them, and that no other speculation has been more or even as profitable. Included in the number will be found mines that have never returned a single dollar in dividends, and some that have been reincorporated, but had disbursed dividends previously. The Belcher, for instance, before its late reincorporations and removal of its office to this city paid out to stockholders $421,200, equal to $405 per foot, and levied assessments to the sum of $410 per foot, aggregating $426,400. The correct total of the Sierra Nevada assessments I was unable to ascertain, as some of the old books have been mislaid or lost, while the secretary of the justice refused to furnish the desired information. The importance of the work which I present to the members of the San Francisco Stock Board for their consideration can only be made manifest by the manner in which it is received and appreciated. It has been a laborious and wearisome task to gather the information which is given in the following statement, and I hope that it will meet with their commendation, and also be the means of informing those who are ignorant of the vast amount that the Comstock and other silver lodes in Nevada have contributed to the wealth of the world.

Companies.	No. assessments.	No. feet in mine.	No. shares in mine.	No. dividends.	Total amount assessments levied.	Total amount dividends disbursed.	Amount assessm't per share.	Amount dividend per share.
CALIFORNIA.								
Amador	....	1,850	3,700	32	....	$836,000 00	....	$226 00
Eureka	....	1,680	20,000	57	....	1,574,000 00	....	78 70
Oriental	8	1,800	18,000	....	$54,000	....	$3 00	....
Union M. and M. Co	1	....	5,000	44	5,000	....	1 00	....
Maxwell	19	....	4,000	....	53,880	....	13 47	1 00
St. Patrick G. M. Co	1	1,800	5,000	...	5,000	....	....	....
Total	....	....	....	...	117,880	2,410,000 00	....	....
WASHOE, NEVADA.								
Alpha Consolidated	5	300	6,000	....	132,000	....	22 00	....
American	3	2,900	11,600	....	52,200	....	4 50	....
Belcher	7	1,040	10,400	....	192,400	....	18 50	....
Bullion	41	2,500	5,000	....	1,077,500	....	215 50	....
Chollar-Potosi	3	2,800	28,000	29	462,000	2,212,000 00	16 50	69 00
Confidence	9	130	1,560	6	218,880	78,000 00	140 00	50 00
Consolidated Virginia	7	1,160	11,600	....	127,600	....	11 00	....
Crown Point	21	600	12,000	16	623,370	858,000 00	51 94	71 50
Daney	34	2,000	8,000	2	436,000	56,000 00	54 50	7 00

Tabular statement of the number of assessments, &c.—Continued.

Companies.	No. assessments.	No. feet in mine.	No. shares in mine.	No. dividends.	Total amount assessments levied.	Total amount dividends disbursed.	Amount assessm't per share.	Amount dividend per share.
WASHOE, NEVADA—Cont'd.								
Empire Mill	6	75	1,200	21	$90,000	$513,000 00	$75 00	$428 00
Exchequer	8	400	8,000	....	128,000	....	16 00	....
Flowery	1	3,600	12,000	....	12,000	....	1 00	....
Gold Hill Quartz	4	13¼	500	8	35,000	41,250 00	70 00	82 50
Gould & Curry	9	1,200	4,800	36	561,600	3,826,800 00	117 00	797 25
Hale & Norcross	34	400	8,000	34	610,000	1,518,000 00	76 25	189 75
Imperial	10	184	4,000	30	450,000	1,067,500 00	112 50	266 87
Julia	29	2,000	10,000	....	106,200	....	10 62	....
Justice	11	....	....	....	....	....	....	....
Kentuck	4	95	2,000	32	70,000	1,252,000 00	35 00	626 00
Occidental	5	....	10,000	1	165,000	20,000 00	16 50	2 00
Ophir	18	1,400	16,800	22	1,064,000	1,394,400 00	73 33	86 25
Overman	15	1,200	12,800	....	632,688	....	49 38	....
Savage	5	800	16,000	52	468,000	4,288,000 00	29 25	268 00
Segregated Belcher	13	160	6,400	....	180,800	....	28 25	....
Sierra Nevada	35	....	20,000	11	450,000	102,500 00	22 50	51 25
Succor M. and M	...	....	22,800	....	....	....	....	....
Yellow Jacket	14	1,200	24,000	19	1,518,000	1,884,000 00	63 25	78 50
Total	...	....	....	....	9,836,038	19,112,050 00	....	....
WHITE PINE, NEVADA.								
Consolidated Silver Wedge	...	....	20,000	....	....	....	....	....
Consolidated Chloride	3	....	50,000	....	250,000	....	5 00	....
Hidden Treasure Consolida'd.	2	600	12,000	....	9,000	....	75	....
Mammoth	7	1,800	36,000	....	55,800	....	1 55	....
Noonday	6	....	20,000	....	32,000	....	1 60	....
Metropolitan M. & M	2	4,000	10,000	2	40,000	10,000 00	4 00	1 00
Original Hidden Treasure	3	....	21,333	....	95,399	33,499 50	4 50	1 50
Silver Wave	5	1,600	20,000	1	102,000	....	5 10	....
Silver Vault	4	3,000	30,000	....	6,000	....	20	....
Virginia	3	800	21,333	....	36,000	....	$45 pft.	....
Total	...	....	....	....	625,399	43,499 50	....	....
BATTLE MOUNTAIN DISTRICT.								
Nevada Butte	1	4,200	40,000	....	40,000	....	1 00	....
ELY DISTRICT, NEVADA.								
Meadow Valley	7	....	60,000	4	210,000	270,000 00	3 50	4 50
Raymond & Ely	...	4,000	30,000	....	....	30 000 00	....	1 00
Total	...	....	....	....	210,000	300,000 00	....	....
EUREKA DISTRICT, NEVADA.								
Eureka Consolidated	...	....	50,000	2	....	87,500 00	....	1 75
Jackson	...	....	50,000	....	....	....	....	....
Mineral Hill	...	....	50,000	....	....	....	....	....
Total	...	....	....	....	....	87,500 00	....	....
Grand total	...	....	....	....	10,829,317	21,953,049 00	....	....

LANDER COUNTY.

Reese River district.—The Lander Hill mines are at present practically the only ones worthy of notice in Reese River district, no others of any note being worked. The veins of this hill have been so often and so correctly described, that it is impossible to add anything of interest to essays formerly brought before the public. Much expense has been occasioned in working the Lander Hill mines by the frequently occuring faults in all the veins, which sometimes throw their lower portions hundreds of

feet out of the plane of the upper part. The veins being narrow, this has, in spite of their richness, brought about the abandonment of many, and at the time of my visit only the North Star and Oregon mines of the Manhattan Company, and the Buel North Star (belonging to an English company) were at work. I mean to say that these mines are the only ones of note now worked; many others are worked in a small way, yielding, perhaps, one or two tons per month, but they hardly pay their way. The ores of all these veins are, as is well known, ruby-silver, dark and light, polybasite, enargite, stephanite, and principally fahlerz; silver-glance is rare.

A pleasing peculiarity of the veins is, that the ores in them do not get poorer in depth, but they have rather improved so far. This will, of course, have its limits; but this much is certain, that the future of these mines is as assured and certain as it can be in the best of mines.

The difficulty of cheap reduction of these refractory ores has been most happily overcome by the Stetefeldt furnace. One of this kind has been built at the Manhattan mill, the construction of which differs somewhat from the former pattern, and with which highly favorable and gratifying results have been reached. I will only introduce a short sketch of this furnace here, and, what is most important, the results of the first month's actual working, as derived from the certificate of Mr. Allen A. Curtis, the efficient agent of the Manhattan Company, to whose foresight and sagacity the company is principally indebted for the introduction of the furnace. The Stetefeldt furnace at the Manhattan mill is larger than that at Reno, and instead of being heated by a wood fire is heated by the gases produced from charcoal in two gas-generators. A third generator produces the gases for heating and chloridizing the dust drawn over into the main flue by the strong draught.

The impression at once received by looking at the furnace is that of an extremely solid and strong work before you—one that is not apt to require many repairs for years to come; and, in fact, in this lies one of the main features of the furnace, so well illustrated by the one at Reno, which has now been continually running for over a year without requiring the least repairs. And the Reno furnace is not nearly as well built as that in Austin. Any one who knows what an expense is continually incurred by the repairs necessary in reverberatories will be able to appreciate this feature of the furnace. Its entire height from the cooling floor to the hopper is nearly thirty feet; while the actual distance through which the pulverized ore and salt fall against the flame is about eighteen feet. The flame from the generators enters the furnace a little over six feet above the cooling floor, and the bottom of the flue above is four feet six inches below the top. The inside size of the shaft, at its lower end, is five feet square. The bottom inclines toward the discharge door, and tapers toward the top, where the size of the shaft is reduced to three and a half feet square. The feeding machinery is a very perfect arrangement, but it is not easy to describe it without the aid of drawings, and I must be content to say here only that it sifts the ore into the furnace, finely divided, in a continual shower.

A very extensive system of dust-chambers is connected with the furnace. As the dust has to pass the fire-place in the main flue before it can reach them, the ore found here is always the most perfectly roasted. From the dust-chambers the waste heat passes under the large dry-kiln and thence into the chimney. The following are the working results of the furnace, according to Mr. Allen A. Curtis, agent of the Manhattan Company, for the first month:

Quantity roasted per day, 22 tons.	
Labor of eight men, including coolers, \$30 50; per ton	\$1 39
Fuel: 3,100 bushels coal, at 29c., for 312 tons; per ton	2 68
Salt: 53,315 pounds; cost, \$886 38 for 312 tons; per ton	2 77
Total cost of roasting per ton in Stetefeldt furnace	6 84

This compares with the former roasting in reverberatories, as follows:

Labor: 22 men, cost \$2,212 for 347 tons; per ton	\$6 37
Fuel: 236 cords wood, at \$8, \$1,880 for 347 tons; per ton	5 42
Salt: 70,017 pounds; cost, \$1,234 14 for 347 tons; per ton	3 56
Total cost for roasting in reverberatories	15 34

This shows a saving per ton of \$8 51, which is enormous. Mr. Curtis, in his letter, concludes: "I think the saving hereafter will be much greater. The working of the present month (August) will, I judge from tests made thus far, reach ninety per cent. fully."

The Manhattan Company's own mines cannot supply the furnace and mill, and they do, therefore, a great deal of custom-work. They are generally working very rich ores, which, for the month of August, averaged \$300 per ton.

The above refers to a visit to Austin in August. In October the Manhattan mill was still the only one running, and its success kept the district as well as the town of Austin quite busy. Mr. Curtis, the skillful agent of the company, was buying ores from everybody, and was reported to secure for his company immense profits in the business.

It is practically a fortified monopoly, since the company owns the exclusive right to treat the ores of this district in the Stetefeldt furnace, and nothing thus far discovered can compete with that furnace for economy and perfection of working. The actual saving in the expense of treating ore, as now ascertained, is some \$12 per ton; and the yield is, at the same time, considerably higher in percentage of the assay value than that of the old reverberatory process. Consequently, the gain in the treatment of rich ores may be \$20 per ton and upward. There is much complaint in Austin that the prices charged by the Manhattan mill are not reduced, in consequence of this great saving by the new process. It is the same feeling as that shown in Colorado toward Professor Hill. In a certain sense it is natural and justifiable; in another sense it is quite unfair. The miner feels wronged when he receives but half the value of his ore, and finds the mill-man or smelter pocketing the largest share of the profits. But this state of things is natural. Mining, especially as it is carried on in most cases in the West, is a rude and simple business. When bodies of ore are found, they are gouged out and carried to the reduction works. When no more is found, the mine is generally abandoned and a new one opened. With the exception of the exorbitant sums expended in wages, there is little capital involved in such mining work. Much money is wasted; little is invested. Mills and smelting-works, on the other hand, require capital, skill, and business management. They combine commercial with metallurgical risks. They may be ruined by their own failure, by the failure of the mines, or by competition; thus being liable to three dangers, where the mines are only exposed to one. In older countries, where the supply of ores for metallurgical establishments is more regular and secure, the risks are not so great. In this country, and especially in Nevada, it is significant and pathetic to see how almost every stamp-mill has been abandoned, sold at auction, transported to other districts,

tinkered, rebuilt, and sold and removed again, in disastrous repetition. While the sun shines, such an enterprise must make hay in a hurry; for the rainy day is certainly coming.

It is curious that every man in these regions wants to get high prices for his own labor, and to realize 3 per cent. a month on his own capital, while he expects other people to be content with fair wages and 7 per cent. a year. Incredibly enough, it was the popular impression that foreign capital should and would be contented here with the moderate remuneration which it receives elsewhere. In the early days, there was a unanimous Macedonian cry for capital. Well, capital came, to help "develop the country," and to be, for a time, helpless in the hands of labor and speculation. Science came, in obedience to a similar call; and scientific men found themselves classed with charlatans and pretenders, petted so long as they would aid the schemes of speculators, and scorned when they attempted honestly to serve the truth and permanently benefit the country.

But the invocation of the aid of capital is not altogether a one-sided affair. Capital and science have now their hour of revenge. Labor must succumb; speculation must give way; unfortunately, even the interests of the whole community must suffer somewhat for a while; but it is a righteous retribution.

When the Stetefeldt furnace was built and successfully tested at Twin River, the people laughed at it. They did not want any new-fangled notions, merely intended to save a few dollars a ton in treating ore. For some two years the inventor struggled in vain for an opportunity to prove his success, while one of the "practical" men of Austin pronounced the furnace a "chemical monstrosity." The Reno experiments were received with a sort of stupid surprise; and shortly after, the Manhattan Company purchased, for a large sum, the rights for Reese River district. Now, when it is too late, the people are very righteously indignant to find themselves in the hands of a "monopoly." But without this monopoly they would be a good deal worse off; and, moreover, the profits of the Manhattan Company, large as they now are, are no larger than they ought to be, to reward that association and its agent for the outlay of capital, time, and skill which they have made in this district.

But whatever may be the opinion concerning the policy of the Manhattan Company in charging \$30 to \$35 per ton for reducing ores, and returning only 80 to 85 per cent. of the assay value, it is certain that the owners of the Stetefeldt furnace have nothing to do with the matter. They have publicly declared their disinclination to dispose of exclusive territorial rights, and they charge no sum whatever for the privilege of erecting the furnace. Their royalty is fixed at \$2 per ton of the ore treated, in localities where, as in this place, a saving of from six to ten times that amount can be effected.

The dissatisfaction of the Reese River mine-owners culminated in the formation of a company, which intended to repair and open the mill known as the Boston in Austin. I have not learned what inducements this company intended to hold out to miners, and how they expected to compete with the Stetefeldt furnace with their reverberatories, but it is certain that the enterprise was not carried out during 1870.

I have remarked above that the Manhattan Company generally works very rich ores. As an example, I give below a table which is compiled from the books of the Manhattan Company, presenting an extraordinary lot of ore from the district of Secret Canyon, in this county, and that of Mineral Hill in Elko County, all of which were worked during a

fortnight. I doubt if the record of any works anywhere for the reduction of silver ore can surpass or equal the list:

Mines.	Pounds.	Value per ton.
Saratoga	39,512	$786 41
Aurora West	70,000	326 25
Tuolumne	2,100	949 73
Morris & Caple	2,000	2,788 94
Do	7,982	819 91
Dollarhide	3,208	945 00
Oregon	4,288	429 22
Do	5,940	738 31
Do	5,850	809 00
Plymouth	6,386	859 26
MINERAL HILL.		
Northey & Co	2,000	887 92
Do	7,812	937 72
Do	3,410	830 20
SECRET CANYON.		
Page & Corwin	24,832	539 98

While these must be considered grand results, they are by no means as grand as these and other districts are capable of. But we should bear in mind that small lots of very rich ore may build up but will not sustain settlements. The low-grade ore of a district, which is the great bulk of its product, must be relied on to maintain large and prosperous communities. Rich ore benefits the individuals, but the poorer or ordinary grade promotes the interest of the whole. The time has undoubtedly arrived for utilizing those large bodies of ore, worth from $40 to $70 per ton, which have been hitherto wasted or neglected. The period of speculation has passed, and it is time that we should begin to understand and husband our resources. If any miner owns a mine that will produce $40 or $50 ore in any reasonable quantity, he ought to make his title clear, and hold on to the property, for the day is not distant when it will be valuable.

In Lander County especially exists an enormous amount of these ores, which so far have been called low grade, though in older countries they would be considered very rich.

Spring Valley and Cortez districts have contributed small lots of ore toward the aggregate product of the county. Their value will be found in another part of this report, in the assessor's returns of Lander County. In Mineral Hill a Stetefeldt furnace has been erected by Mr. Curtis, the superintendent of the Manhattan Co., at Austin, and I am informed that it was put into operation late in the fall. The ores of the district are reported to be a rich variety of Stetefeldtite. Mineral Hill is about forty miles from Carlin, a prominent station on the Central Pacific road. The district was discovered about two years ago, and now there are five hundred souls located here. Among the most promising and leading mining claims are the following: Keystone, Argentum, Monroe, Norman, Grant, Grey Eagle, Wissahickon, and Austin.

The following are the assessor's returns for Lander County, comprising the four quarters, from July 1, 1869, to July 1, 1870:

Assessor's returns for the quarter ending September 30, 1869.

Mine or company.	Tons.	Pounds.	Average per ton.
REESE RIVER.			
Black Ledge	2	1,680	$297 48
Lodi	4	424	439 58
Harriet Lane	2	271	774 56
Inmol	6	888	173 84
Harding and Dickman	9	606	62 21
Bailey	1	1,410	141 35
Royal American	1	278	63 20
Tuolomne	9	1,980	310 35
Niagara	3	944	248 52
Chicago	2	1,897	255 99
Maggie	7	540	75 20
Baker	7	597	154 80
Shakespeare	2	1,266	379 39
Plymouth	6	1,296	123 23
Kelly	1	308	267 00
Florida	3	609	427 50
Florida, 2d class	17	....	133 74
Lane and Fuller Company	460	1,271	139 12
Lane and Fuller Company, 2d class	35	100	72 13
Jo. Lane	7	338	777 61
Jo. Lane, 2d class	4	1,296	92 29
Troy	11	1,585	464 15
Troy, 2d class	8	632	159 00
S. C. Baker	24	1,632	212 98
Manhattan Company	638	1,592	109 35
Whitlatch Yankee Blade	8	675	337 51
Whitlatch Yankee Blade, 2d class	14	1,074	209 96
Smith Company	2	490	429 76
Kihock	16	1,559	224 79
Homeward Bound	3	1,902	258 42
Wayant	1	264	591 34
CORTEZ.			
Arctic and Garrison	271	1,660	81 12
Walker Company	3	1,829	89 33
Ross Company	26	1,547	122 21
Carter Company	8	695	176 42
Taylor and Passmore	10	241	68 61
Kenney Company	11	1,735	200 84
Berlin	4	531	72 13
Olsen Company	7	1,356	139 60
MINERAL HILL.			
Northey Company	29	932	367 45
Corse Company	6	978	150 59
Godwin Company	1	1,114	228 90
Powell Company	2	512	263 03
Spencer Company	12	1,339	252 08
Yandell Company	3	1,257	109 89
SPRING VALLEY.			
Red, White, and Blue	1	1,596	230 01
Berry Company	9	712	181 75
Grant	1	1,750	385 58
Providence	1	70	58 42
Ross	1	1,290	92 86
Smith Company	1	1,348	529 12
Woods Company	5	1,164	53 16
Williams Company	6	518	235 87
EUREKA.			
Gem	7	514	112 12

Deducting the amount of ore, 56 tons 623 pounds from Mineral Hill, which is in Elko County, we have 1,762 tons 973 pounds as the product of Lander County during the last quarter. The value of the bullion produced amounts to $253,197 60, which is an average of $139 21 per ton. That is about the average of the lot of 460 tons produced by the Lane and Fuller Company. The average of the ore produced by the Manhattan Company is considerably lower than that of several preceding quarters. The average of the ore produced in Reese River district during the quarter is very good; Mineral Hill is high; Spring Valley (in small lots) is fair; while the average of Cortez is lower than usual. The Arctic and Garrison are totally distinct mines in the latter district, yet their product is lumped in the assessor's roll; so that the value of the ore produced by either cannot be determined.

Assessor's returns for the quarter ending December 31, 1869.

The following table comprises the names of thirty-two sources from which bullion was obtained, while the assessor's book specifies eighty-four; but I have omitted all lots of ore less than one ton, as well as all lots where the name of the mine or company is not given. Nearly one-half the entries in the roll of the assessor make no mention of the mine which produced the ore to which certain amounts of bullion are credited.

Mine or company.	Quantity.		Average per ton.
	Tons.	*Pounds.*	
Chester	1	1,898	$248 08
Doyle & Co	7	868	112 53
Kalcseed	2	1,814	333 02
Timoke	3	1,394	155 36
Roman	1	30	194 35
Saratoga	21	1,879	423 09
Silver Circle	2	1,124	97 42
Buel North Star	37	556	100 70
Florida	22	432	337 25
Florida, (west)	13	1,096	330 71
Manhattan Company	360	962	149 15
Whitlatch Yankee Blade	8	1,540	121 29
Maggie	6	918	133 04
Star of the Evening	2	1,846	213 10
Plymouth	2	534	192 34
Chicago	22	310	225 89
Great Eastern, (dump)	3	....	171 29
Harriet Lane	14	282	337 50
Isabella	4	520	181 47
Silver Chamber	2	918	94 00
Troy, (six lots)	33	1,394	258 00
Lewis	3	1,354	583 75
Black Ledge	1	466	316 57
CORTEZ.			
Arctic	76	27	55 66
Garrison	47	964	281 14
St. Louis	25	863	67 56
Mount Tenabo	13	1,546	57 80
Berlin	9	1,593	153 78
EUREKA.			
Buckeye Company	72	1,450	49 08
SPRING VALLEY.			
Providence	2	984	308 48
SECRET VALLEY.			
Telegraph	1	1,078	174 52
Page & Corwin	7	264	435 21

It may be stated that the entire ore product of the quarter is 993½ tons, about one-half the amount produced during the previous quarter. The total value of the ore is $163,475, which gives an average of $164 42 per ton, it being understood that the computations are in gold. During the quarter the lots of ore brought to the mills were mostly small; the only considerable lot produced by any mine or company being that of the Manhattan, the average yield of which is nearly up to that of previous quarters. The only noticeable feature of the returns is the decrease in the product of ore.

The table specifies only one lot of ore produced in Spring Valley, while the assessor mentions ten; but he gives the name of the mine from which the ore was obtained in one instance only; in nine cases it is credited to Black, Brown, or Green. This is true in a less degree of Cortez and Secret Valley.

In conclusion, I must observe that the returns of the assessor contain no information respecting the product of lead bullion in the district of Eureka during the last quarter. Reports have credited that district with producing a considerable number of tons of rich lead, but the assessor's returns give no data by which to verify them.

Assessor's returns of product of mines for the quarter ending March 30, 1870.

Mine or company.	Quantity.		Cost.	Total.
	Tons.	Pounds.		
EUREKA DISTRICT.				
Buckeye	57	928	$48 56	$2,790 88
Champion	298	582	48 56	14,487 28
SECRET CANYON DISTRICT.				
Page & Corwin	10	1,030	460 94	4,846 87
REESE RIVER DISTRICT.				
Whitlatch Mine	12	1,290	333 69	4,219 53
Do	3	846	228 49	782 15
Saratoga	36	1,914	446 30	16,494 25
Tuolumne	15	602	193 97	2,580 11
Chicago	12	1,500	122 30	1,559 45
North Star	458	196	150 23	68,822 12
Oregon and North Star	83	1,076	322 97	26,980 36
American	17	430	160 64	2,763 95
Isabella	12	226	323 76	3,921 71
Buel North Star	107	468	166 06	17,808 08
Troy	78	42	161 55	12,604 50
Do	0	746	133 83	49 92
Do	1	318	316 22	366 50
Do	4	1,980	115 69	577 31
Do	4	1,730	157 72	752 75

Total number of tons of ore raised in Lander County, 1,457$\frac{1230}{2000}$ tons; value, $228,896 83. All small lots from various mines, not named, are omitted in the above table.

Assessor's returns of product of mines for the quarter ending June 30, 1870.

Mine or company.	Quantity.		Cost.	Total.
EUREKA DISTRICT.	*Tons.*	*Pounds.*		
Champion	1,017		$64 50	$65,596 50
Butter-Cup Company	180		45 55	8,199 00
Home Ticket	44	856		1,110 70
Jackson	333	500	25 00	8,155 00
Do	460	699		11,180 58
Richmond	17			522 31
Husick	10	1,000		210 00
Bullwhacker	70	1,517		1,415 17
Wilson	20	1,561		571 96
Big Bilk	12	918		186 89
Lord Byron	11			330 00
Southern Pacific	18	733		551 00
SECRET VALLEY DISTRICT.				
Page	48			7,630 00
Bacy	10			300 00
Badges	27			540 00
CORTEZ DISTRICT.				
Mt. Tenabo	46	233		3,011 22
Garrison	17	1,981		3,978 77

There are no returns from the Manhattan Company in Reese River district, on account of the building of Stetefeldt furnace. Total ore raised and reduced in the county, 2,397 tons; value, $119,488 41. All small lots below 3 tons, from various mines, and those from mines not named, are omitted in the above table.

Eureka district.—This district has attained high prominence during the year. It has been known for about six years as a region which contains base metal ores, but the discoveries previous to the fall of 1869 were not such as to cause the district to be regarded as of much value. All this is now changed, and Eureka may safely be classed among the most promising districts in the State of Nevada. The rapid advance in the monthly yield of bullion points so strongly to this, that even the outside observer is forced to come to such a conclusion; but to those who have visited the district and its mines, and who can appreciate a real not fancied abundance of ore, the fact is quite evident.

Eureka district is situated in Lander County, Nevada, about forty miles west of Hamilton, and sixty-five miles east of Austin, in a spur of the Diamond range of mountains. The prevailing rocks in the district are dolomitic limestones, quartzites, sandstones, slates, and occasionally these stratified rocks are capped by a coarse-grained, white, trachytic tuffa. This district compares very favorably with most others in Nevada, in regard to the abundance of wood, grass, and water.

The first silver mines were here discovered about six years ago. They lie in New York and Secret cañons, and occur in limestone. The ores in these are sulphates, antimoniates, and carbonates of lead, carrying from $20 to $200 silver per ton, and stetefeldtite, galena, and a mineral similar to bournonite. They are very quartzy, and the deposits are rather limited.

Some of the most promsing of these mines were sold to a New York company, and considerable money was expended. An effort was made to smelt the ore, but the same fate that seems to have followed most investments of eastern capital followed this, and the mines were

pronounced a failure. The ore contained too much lead to permit of successful working (even by roasting previously) by the mill process, and the district was virtually abandoned until 1868, when Major McCoy, Jerry Miller, and their associates, finding that the ore in the district was very rich in lead, and contained a large amount of silver, and considerable gold, employed Mr. Stetefeldt to erect a furnace, which was put in operation in the spring of 1869, with at first poor success, though results were not altogether discouraging. About this time a number of miners visited this district from the White Pine, and other valuable mines were discovered and located.

In the fall of 1869, Colonel G. C. Robbins built a small furnace at Eureka, and demonstrated that the ores could be successfully smelted. Soon after, the McCoy furnace made a more successful run on ores from the new mines. About this time Colonel David E. Buel, in company with others, leased the McCoy furnace, and bonded the Buckeye, Champion, and Sentinel mines. The ore was worked successfully, it being of a character very well adapted to the smelting process. The mines carrying these excellent smelting ores are located on Mineral Hill, two and a half miles west of the town of Eureka. They have secured the future of the district, and are certainly the most extensive deposits of middling high-grade ores at present known in Nevada. Although carrying a high percentage of base metals, they are, nevertheless, the most valuable mines discovered during the last four or five years. At the locality where these deposits occur, the rock strata are highly inclined, and the ores occupy a zone running with the strike of the strata, and either at or very near to the contact line of limestone and quartzite beds. This zone has been followed for miles, and deposits of greater or less magnitude have been found everywhere. The quartzite is nearly always the foot-wall of the deposits, while the limestone may be termed the hanging wall; sometimes, however, the ore lies entirely in the limestone, a short distance above the quartzite. The Buckeye, Champion, Jackson, Sentinel, and Richmond, are at present the most important mines. On these the most work has been done, and huge deposits are fully exposed to view. The Buckeye and Champion, for instance, have been worked to a large extent as open quarries, and to prove the continuance of the ore in depth, two shafts have been sunk in the Buckeye, 75 and 65 feet in depth, respectively. The two are connected by a level, which passes on in opposite directions from both shafts for some distance, so as to make the whole length of the level 75 feet. In this level is a chamber 16 feet square, cut out in the ore, which does not touch the limits of the deposit on either side. A cross-cut at another place, 30 feet in length, has also failed to define the width. The Buckeye and Champion are close together, and are both owned by the same San Francisco company, which bought them, together with the Sentinel, another adjoining mine, from the original discoverers, for $100,000. It was an exceedingly low price, especially as there were some 2,000 tons of ore on the dump at the time of the purchase. This ore, in fact, is all that was paid for, as will appear from the assays to be given hereafter.

The history of the formation of the present Eureka Consolidated Company is related as follows: After Colonel Buel had satisfied himself of the smelting qualities of these ores, he resolved at once to build large smelting works, and a company was formed, consisting of Buel, Bateman, Allen, Ingoldsby, and Farren, and called the Bateman Association, who took the matter energetically in hand. No sooner had Mr. Wm. Lent effected the purchase of the Buckeye property, which consists of six locations, than he effected a consolidation with the Bateman Asso-

ciation, thus uniting one of the largest properties in the State. The new company, known as the Eureka Consolidated Mining Company, now holds the following mines: The Buckeye, Champion, Sentinel, Central, Roseland, and Mammoth, together with the smelting works erected by Buel and Bateman.

From the Champion, ore has been taken from an open cut about 25 feet deep, 16 feet wide, and 25 feet long, and from a large chamber about 20 feet square, which is heavily timbered. The only outcrop of this tremendous deposit was a three-inch crack in the limestone, filled with hydrated oxyde of iron. A blast put into the limestône threw off a thin cap of not more than six or eight inches, which covered the whole deposit, and which is again overlain in several places by earth from four to six feet deep. The ore is an earthy carbonate of lead, in which lumps of undecomposed galena are found. This galena is almost invariably covered with a thin crust of a product of the decomposition of galena and arsenical pyrites, which is probably analogous in composition with stetefeldtite, and in which the antimoniates seem to be replaced by arseniates. This crust is much richer in silver and gold than the galena or carbonates. Mixed with the latter occurs considerble arseniate of iron, easily recognizable by its color and by blow-pipe tests.

The following averages of the assays of the ores smelted up to the end of April, comprising many thousand tons, will give an idea of the richness of these ores:

	Silver.	Gold and silver.
Champion	$67 53	$75 70 per ton.
Buckeye	75 75	83 60 "
Jackson	81 10	

The figures are taken from the assaying records of Messrs. Jungjohn & Hartwig, and vouched for by them. The contents of gold are about $40, the balance is silver, and the contents of lead, from 40 to 50 per cent., are not included. A lot from the Empire, a mine lying in the same zone as the foregoing, has assayed as high as $96 gold and $186 silver per ton. The ores are so easily extracted with pick and shovel alone, that one man can take out ten tons per day, and two miners have actually so far supplied the two furnaces of the company.

A second group of mines, the Grant, Sunburst, Ione, Summit, Esmeralda, &c., are situated on Mineral Hill, southwest of the Buckeye. The ores here are mostly stetefeldtite, and carry much quartz. They are, however, very rich in silver and gold, and assay from $80 to $800 per ton; but the occurrence is irregular and nest-like. The Sunburst seems to contain the greatest quantity of ore.

Northeast of the Champion, and in the same mineral-bearing zone, across a cañon, a number of very promising mines have been lately discovered by Loucks, Rigsby & Co. The East Star and Wide West are the most prominent, and have been traced over 1,000 feet. The deposits lie also under a thin cap of limestone, and carry below this an iron cap of little depth. The following assays, made by the before-mentioned assayers, have been furnished me:

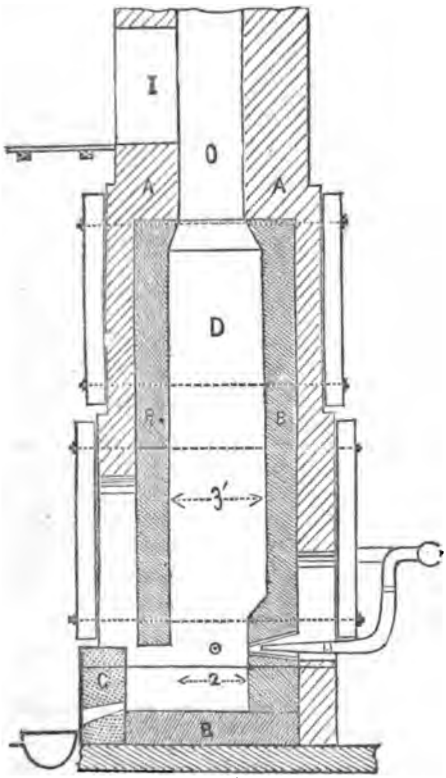
Samples from mines of Loucks, Rigsby & Co.	Silver.	Gold.	Lead.
1	$404 33	$63 00	25 per cent.
2	151 93	30 00	
3	77 46	18 00	
4	59 56	18 00	
5	372 10	48 00	
6	452 40	72 00	

An average, taken of all these samples after crushing and mixing, gave $307 26 silver, $42 gold, and 12½ per cent. lead. In these same claims an iron ore is found close under the limestone cap, and embedded in the carbonates, which assays $300 10 gold and $16 96 silver. It is probably a product of decomposition of the arsenical pyrites which are found undecomposed in the galena below.

Before closing this description of the mines in Eureka, I must mention a peculiar ore occurring in the Page and Corwin, a very important deposit in Secret Cañon, seven miles south of Eureka. This ore is evidently a product of decomposition of iron pyrites and antimonious ore, but assays up to $2,000 per ton in silver. It mills from $200 to $500 per ton, according to selection. The quantity exposed is very large, as may be seen, when I mention that the chamber opened is 40 feet in diameter. The ore is sent to Reno, and is there roasted in the Stetefeldt furnace, and worked in the mill, or to the Manhattan Mill at Austin.

The carbonates and galena ores of the district are smelted at Eureka, as before mentioned. The district commenced producing regularly last December. All that time only one furnace, McCoy's, was in operation. Now there are fourteen furnaces built in the district, all in and close to the town of Eureka. Six of these furnaces were running at the time of my visit. These are all built after the same general pattern, which is not a very good one, as I shall show hereafter.

On the 30th of June, the results of previous smelting in Eureka were as follows:



Shaft Furnace—vertical section.

Bateman Association (two furnaces) had produced 373 tons, average value $348 per ton	$130,152
Marcelina Mining Company, of San Francisco, 200 tons, average value $350	70,000
McCoy Furnace, 110 tons, average value $450	49,500
Buttercup Mining Company, of New York, 100 tons, average value $375	37,500
Wallace & Bevan, of Philadelphia, (two furnaces) 75 tons, average value $3 50	26,250
Total, 959 tons	313,402

Thus showing that the large quantity of 859 tons of lead bullion, with an aggregate value of $313,402, was produced by this district in the first six months of smelting, the major part having been actually produced, however, during the last three months.

Mr. Guido Kuestel, a mining engineer and metallurgist, well known on the Pacific coast, has had occasion to visit Eureka during last summer. In the Scientific Press he describes the smelting operations and furnaces of Eureka as follows:

They are vertical blast or cupola furnaces, with a square horizontal section. The

blast is admitted through three tuyeres, one at the back and one at each side. The mouth or nozzle of the tuyeres is generally three inches in diameter, admitting a very large amount of wind—too much, considering the horizontal dimensions of the furnaces, which are about two feet square, and the easy fusibility of the ore. The shaft is from twelve to sixteen feet high, from the tuyeres to the charging hole. The hearth is about two feet below the tuyeres, and is made of stone, the front part alone being formed of a composition. At the bottom of the hearth is the tap-hole, through which the lead is run out at intervals. One tapping gives about 200 pounds of pig lead, which being run into molds, forms bars weighing from 80 to 120 pounds apiece. The furnace is built of stone found here, lined inside with a fire-proof sandstone, which is found at Pancake Mountain, about twenty miles distant. This last is porous, and of an excellent quality. Lately sandstone equally as good has been found at Eureka. The blast is furnished by fan-blowers. The illustration shows the common style of furnace used. Here A denotes the walls, built of a sort of porphyry tufa; B, the inside lining of sandstone; C, the front of the hearth, of composition. The shaft D has a square horizontal section, and the shaft O a circular one. I is the charging hole.

The ore is principally cerussite or carbonate of lead. There is also some galena, but only in limited quantities at present, and mostly changed into a dull, black mineral, retaining the structure of galena, and apparently unchanged in the center. Singularly enough, the dull portion is richer in silver than the galena, from which it seems evidently to have been formed, perhaps by the influence of internal heat. It resembles stetefeldtite. On an average, the ore prepared for smelting contains 40 to 48 per cent. of lead, $60 to $80 in silver, and $15 to $20 in gold per ton. In bulk, the ore has a yellow color, due to the iron in it. There is also arsenic in the ore, which, in smelting, combines with the iron, forming a white compound (speiss) somewhat like matte, and holding $36 to $45 per ton in silver and gold, and 24 per cent. of lead. The ore smelts readily by itself, nothing being added except about 20 per cent. of slag.

Analysis of the slag shows the following composition. For the sake of comparison, the composition of a Freiberg slag is also given. No. 1 is the slag from Eureka, and No. 2 that from Frieberg:

	No. 1.	No. 2.
Silica	30.20	36.50
Iron (suboxide)	50.60	40.50
Alumina	3.01	8.50
Lime	7.10	4.00
Magnesia	0.90	3.00
Lead (oxide)	8.70	7.50
	100.51	100.00

To form this requires 2,660° Fahr., and to melt it when formed, 2,402°.

There is a little too much iron in the slag No. 1. For the protection of the furnace lining a somewhat larger proportion of quartz in the ore would seem to be advantageous. Yet as it is, there is a most fortunate coincidence of all the requirements for easily smelting the Eureka ore. About 24 pounds of charcoal are charged into the furnace at one time, and from 40 to 45 pounds of ore, besides 12 pounds of slag. The charging is done in a very irregular manner, by shovels, and without weighing or measuring. One furnace can smelt from eight to nine tons of ore in twenty-four hours. Three and a half tons of ore yield about one ton of pig lead, or "bullion," as they prefer to call it. The consumption of charcoal varies from 30 to 35 bushels to the ton of ore. At present, it costs about $20 to smelt a ton of ore; it is probable, however, that by using a furnace of larger capacity, the expenses may be reduced to $14 or $15.

When the furnaces are properly managed, the loss of lead will probably not exceed 20 per cent. At present, however, it is larger, owing to several reasons, and very largely to the very frequent use of crowbars about the hearth, whereby a great deal of lead is mixed in with the slag. By using such large tuyeres, it would seem that too much wind was brought into the furnace, and without sufficient pressure. Hence the heat is not concentrated in the smelting region just above the tuyeres, but is diffused in the upper part of the furnace, and the carbonate of lead commences to melt at a distance of one or two feet below the charging hole, and the lead is thus exposed a long time to volatilizing influences. Hence, also, in the hearth the temperature is too low, the slag stiffens, sticks to the walls, makes the constant use of the crowbar necessary and takes up mechanically considerable lead. Again, the ambition of having a very long run induces some smelters to keep the furnace at work when it evidently needs repairs, and this is another source of loss of lead and silver.

The amount of speiss (the combination of arsenic and iron) is about 3 per cent. of that of the ore. At present this is not treated further.

The bullion contains on the average about $170 in silver and $80 in gold, or a total of $250 per ton. This statement must be taken, of course, as a very general one. The lead is at present shipped to Newark, New Jersey, for the purpose of extracting the

silver and gold. There is nothing to prevent its being cupelled at Eureka, but different circumstances induce the companies to send it away.

A large furnace, with five tuyeres, and capable of smelting 24 tons in twenty-four hours, is now being built by the Eureka Smelting Company, under the superintendence of Mr. Ch. Von Liebenau. This furnace will be six-sided, and in the middle of each side, except the front one, comes a tuyere directed towards the center of the furnace. The diameter of the furnace, or rather the distance of the centers of opposite sides, is three and a half feet at the level of the tuyeres, and four feet at the level of the feeding hole. From the tuyeres to the feeding hole is 16 feet. The furnace will cost between $2,500 and $3,000.

This description is generally quite correct, and it will only require a few additional remarks to make it complete. At the same time I will try to point out the very serious defects which the present system of smelting is suffering under. Not all the furnaces are rectangular inside. I know of at least one which is round. From the sketch it can be seen that the furnace here figured has a sort of bosh on three sides, commencing about 1½ feet above the tuyeres. Above, and just below the charging hole, the shaft is also contracted, and the chimney is a foot narrower than the shaft.

This form of the furnace tends greatly towards the formation of iron sows, and also toward volatilization of an enormous quantity of lead oxide, which carries always silver with it. Mr. Kuestel, in his article, does not give the result of experiments made by him and Mr. C. Von Liebenau, at Eureka. According to these, I am informed from the most reliable source, *i. e.*, one of the experimenters themselves, 30 per cent. of the silver and 40 per cent. of the lead contained in the ore are lost at present, and this is really enormous. Another very bad feature of the Eureka furnace is the large size of that part of the crucible lying outside of the breast. In fact, the whole of it, two feet wide and about one foot deep, is left entirely open. The consequence is, that a great amount of coal is necessary to cover up this space; that the heat, which spreads too much upwards anyhow, on account of the large quantity of insufficiently compressed blast, cannot be maintained in the crucible; that the slag, which is a low silicate, and is therefore inclined to stiffening, becomes cold and short, and mechanically incloses particles of lead which go over the dump. This takes place the more, as iron is also reduced from the charge on account of the long time it is kept in a reducing zone on the boshes, and bars are therefore frequently introduced to loosen it. To do this the fore-crucible is opened and more heat is lost. Considerable silver has heretofore also been lost in the speiss which, to within a short time ago, went over the dump as "white iron." It is now saved, but not treated further for the present. I am informed that part of the dumps, especially the oldest around the Eureka furnaces, assay as high as $80 per ton in silver.

As will be seen from Mr. Kuestel's article, the proportion of coal used per ton of ore is extravagant for ores as easily fusible as those at Eureka. This is partly caused by the construction of the furnaces; but a great deal of it is also due to the treatment of the coal, which is transported in sacks instead of racks, and exposed to all kinds of weather, so that it always contains a large amount of moisture, and is rather small and soft.

In my opinion, the improvements required in Eureka to make smelting extremely profitable are: 1. More careful burning of the coal, so as to obtain it hard, in larger pieces, lustrous and ringing; transportation in racks in the way done in Pennsylvania, New York, and the Eastern States generally. 2. Roasting of the ores in free heaps, with intermixture of small coal to volatilize part of the arsenic and sulphur. This

ought to be done at the mines, where wood is much cheaper than in Eureka. 3. The furnaces must be differently constructed, *i. e.*, the walls must come down straight to the hearth, or contract gradually about one foot in the whole height from top to bottom, like the Raschette or the Piltz furnaces; the mouths of the tuyeres ought to be narrowed from three to one and a half inches, and pressure blowers ought to be employed instead of the fan-blowers now used. The fore-crucible ought to be closed, so as to protrude not more than four inches from the breast at the commencement of the campaign, and not wider than six inches. 4. As long as no dust chambers can be connected with the furnaces, (which would undoubtedly be the best,) the stack ought to be rather wider than the furnaces than narrower, so that the draught may be reduced to a minimum, and thus the escape of dust be prevented as much as possible. 5. Regular charges ought to be carefully mixed on the charge-floor, before the ore goes into the furnaces, which is not done now. The quartzose silver ores from New York and Secret Cañons, and no slag, should be mixed with the carbonates, so that a slag between a singulo and bi-silicate would be produced. Such a slag being hot, light, and not inclined to stiffening, mechanical losses of lead would be prevented, and the furnace-walls and crucible would last longer.

The Eureka Consolidated have been chiefly running on Champion and Buckeye ore, which is so easily mined that the whole cost of mining and hauling over two miles to the furnaces is only $4 25 per ton. In the fifty-six days immediately preceding the 30th of June, they smelted 765 tons 368 pounds of ore, which gave 238 tons of bullion, gross returns, for which, from New York, gave $348 per ton. The quantity of charcoal consumed was 25,832 bushels, worth 30 cents per bushel, delivered. From these figures it will be seen that it took about three and a quarter tons of ore to make one ton of bullion, and required, say, thirty bushels of charcoal to smelt one ton of ore. Ores from some twenty-five or thirty other mines have been smelted in the various furnaces, and the results show about the same figures. It may therefore be safely noted that in the Eureka district three and one quarter tons of ore make a ton of bullion, and thirty bushels of charcoal are required to smelt one ton of ore.

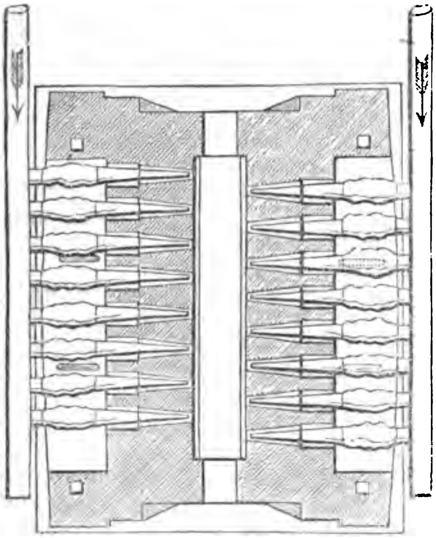
The above account was prepared for this report in August, 1870. Since then the Piltz furnace, in the course of erection at that time, has been completed by the Eureka Consolidated Company, and has proved a perfect success. Much of the former loss, occasioned by the unsuitable construction of the older furnaces, is entirely avoided in this one, and the consequence is a cheaper smelting and a higher yield in lead and silver.

The following article from the pen of Mr. Guido Kuestel, which appeared lately in the Scientific Press, gives a sufficiently clear idea in regard to the construction and working of the Piltz furnace, to answer all purposes for the present:

The want of furnaces so constructed as to permit the smelting of larger quantities of ore than hitherto effected with the old styles, led first to the introduction of the "Raschette" system, an arrangement by which the tuyeres, the form of the smelting space being rectangular, are placed in two rows, one of seven or eight on each long side, and are so arranged that the blast of one side strikes between that of the tuyeres of the other side. The figure, which gives a section of the furnace, explains this. The discharge of metal and slag takes place on the two narrow sides. The smelting result of these furnaces is greatly superior to that of the old-fashioned ones with one or two tuyeres, not only with reference to the larger quantity of ore smelted, in a given time, but also in saving a greater percentage of metal and fuel. The treatment of such a furnace, however, is delicate, and it required many months running before, by gradual improvement, a long smelting campaign was secured.

It is surprising that the rectangular shape was preferred to a circular one, for in-

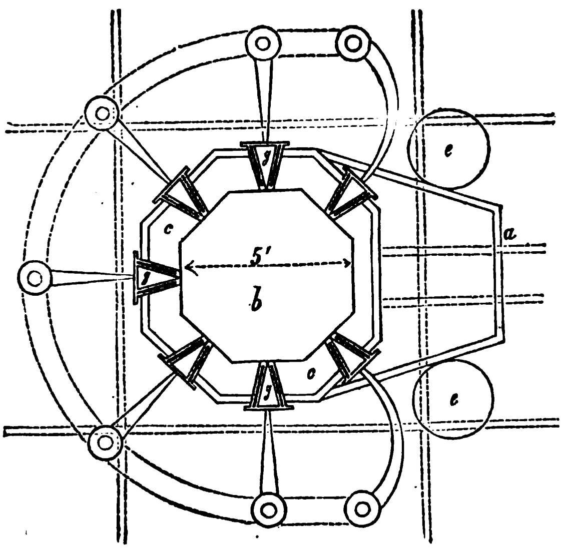
stance, one like the old iron-assay furnace of Sefstroem, with blast holes at equal distances on the periphery, the very effective result of which was well known. Mr. Aubel gave an elaborate description of Raschett's furnace, alluding in the same to the circular shape. By theoretical reasoning he tried to prove that a circular form does not admit of a uniform smelting region, and that the consumption of fuel in the center would be a useless one. Notwithstanding this theory, Mr. Piltz, of Freiberg, Saxony, constructed a circular furnace, 5½ feet in diameter in the clear, and with eight tuyeres, which has proved very successful, and which it is now proposed to describe.



The Raschette Furnace—section through the tuyeres.

For the sake of greater convenience in building, an eight-sided shape was chosen.

The first furnace of this kind was built, if I am not mistaken, about four years ago, at Halsbrucke, near Freiberg. From the start, the result was so favorable and so superior to Raschett's that, with slight modifications in regard to dimensions and number of tuyeres, at this time no other furnaces are in use at Freiberg. Aubel's theory did not prove to be correct. In a properly regulated smelting operation, no so-called "pigs" are formed either in the center or elsewhere; the slag runs continually, undisturbed by crowbar operations, which usually are frequently necessary in other furnaces on account of clogging up, etc.

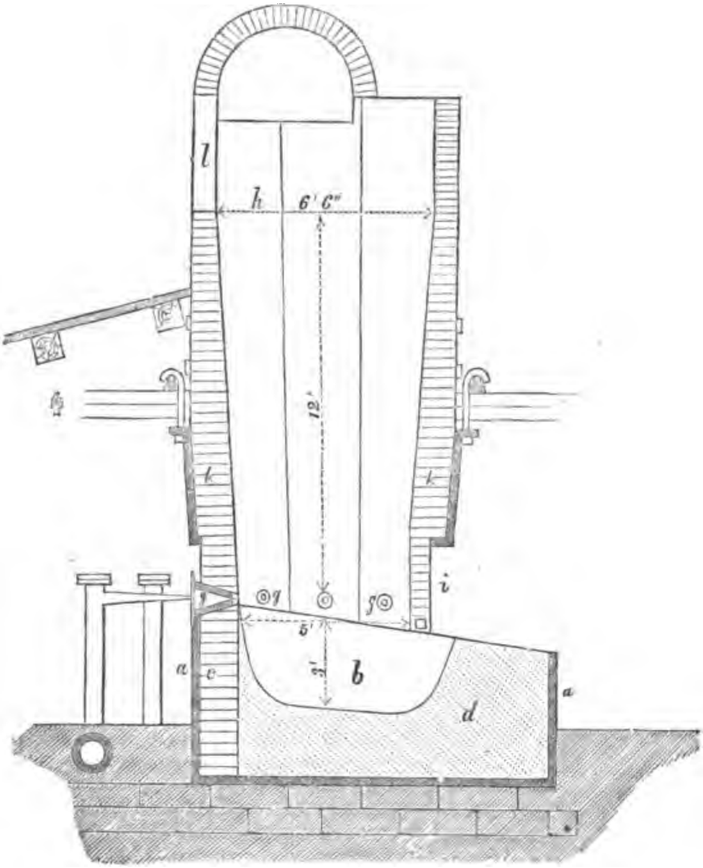


The Piltz Furnace—horizontal section.

The figures show a horizontal and vertical section of one of Piltz's furnaces. At *a* is represented a cast-iron box, in which the brick-work, *c*, is placed, and the remaining space beaten out with a composition, varying with the nature of the ore, generally being composed of one part of clay or loam and one part (volume) of charcoal, coke or anthracite, all powdered, mixed and moistened slightly. This composition is beaten in as hard as possible by means of wooden or iron pestles, and either the space is entirely filled and the crucible or receiver, *b*, then cut out, or the crucible is shaped during the stamping. The first method is preferable. There are two, sometimes three, tap-holes, leading the metal into the kettle, *c*. Above the crucible are seven tuyeres, *g*. The distance from *g* to the bottom of the hearth is 3 feet, and from *g* to the feeding-hole, *l*, 10 feet. In case eight tuyeres are used, the last one is placed in front at *i*, a few inches higher than the rest, having at the same time a small inclination, so as to direct the blast to the same point in the center toward which are directed the other seven, which lie in a horizontal position. The breast, *i*, rests on a hollow cast-iron pipe, cooled by a constant current of water, as are the tuyeres. The upper part of the wall, *k*, is suspended in a cast-iron mantle. The advantage of this arrangement lies in the convenience and facility with which the fire-bricks above the tuyeres, which are mostly exposed to the action of heat and of dissolving substances, can be removed

and replaced without interfering with the upper part. Being suspended, there is also free access to the furnace from all sides. In place of the "hanging suspension," other furnaces of the kind are provided with three or more iron pillars on which the upper masonry rests. The height above the tuyeres differs often greatly up to 20 feet. The section of the furnace widens always toward the feeding-hole, as this has a beneficial

Fig. 3.



The Piltz Furnace—vertical section.

effect on the result of smelting. The force of the blast, finding a larger space in the upper region, is diminished as well as the heat, and the ore dust carried out does not amount to more than 1 per cent. The feeding aperture is at *l*. The gases, etc., enter dust-chambers before escaping through the chimney.

One of these furnaces is attended by one smelter, two slag-wheelers and three men to feed. Ore and fuel are regularly charged. The metal is tapped, from 18 to 20 times in 24 hours, into one of the two or three tap-kettles alternately. The slag runs continually into a slag-pot of cast iron of a pyramidal shape, the base being up. This cone is 29 inches high and 22 inches in diameter on the top. Matte, or globules of metal sink through the yet liquid slag to the bottom, in case any should be carried out. When stiff, the pot is turned over, the end of the slag-cone (where the metal or matte collects) broken off and melted over with the ore.

The blast or quantity of wind required is not very great—for each nozzle, about 125 cubic feet per minute, or for seven tuyeres 875 cubic feet, at a pressure of 1 inch quicksilver.

In the year 1868, a Piltz furnace, 20 feet high, smelted in 28 days:

	Tons.
Lead ores	545.00
Piritous ores	50.30

	Tons.
Matte and hearth from cupellation, etc	220.35
Slag	329.25
Magnetic iron ore	61.00
Limestone	14.00
Total	1,219.90

From these were obtained:

	Tons.
Matte	224.00
Lead	178.26
Silver	1.40
Slag	646.50

The slag contained 1.56 per cent. of lead and 0.71 oz. of silver per ton. The above 1,219 tons of smelting material (which are put into the furnace mixed together) consumed 109.8 tons of coke, (middling quality,) or 9 per cent., while the old Freiberg double-furnaces consumed 14 per cent., and other furnaces 20 per cent. and over.

According to the census returns the mines and smelting works at Eureka produced up to June 1, 1870, the following:

Eureka Consolidated Company, with 25 men, in six months	$295,000
Buttercup Company, with 15 men, in four months	50,000
Jackson Company, with 23 men, in five months	120,000
Page & Corwin, (milling ores,) with 20 men, in twelve months	135,000
Total	600,000

This is, however, the product of seven furnaces and one mine, which sends her ores to Reno and Austin to be amalgamated; and of only a part of the year. The actual yield of the Eureka mines for the calendar year 1870 is not less than $1,200,000. Toward the latter part of the fall Messrs. Ogden & Dunne commenced the construction of cupelling works at Eureka, which were expected to be ready for work in December.

The yield of the district increased steadily, and the bustle of active and prosperous business was apparent on all sides. In October, the Eureka Consolidated produced 222 tons bullion, worth $300 per ton. The two Buttercup furnaces produced 6 tons bullion per day. The Jackson Company's furnaces produced in October 92½ tons bullion, worth $350 per ton. In the mean time new mines were discovered continually in the neighborhood, and at present it may be truly asserted that Eureka is one of the foremost districts on the Pacific slope. This view is supported not only by the number of good mines already known, but principally by the fact that these mines carry base metal ores, which all over the globe have been found to be the most permanent.

The total population of Lander County, according to the late census, is 2,815; 218 of which are Chinese.

NYE COUNTY.

Silver Bend or *Philadelphia district*, which attracted so large a share of the attention of mining men a few years ago, and was soon after almost deserted, has taken a fresh start during the last year.

This is principally due to the Transylvania and El Dorado lodes, from both of which rich ore has been extracted and worked, partly at Belmont, in Mr. Canfield's 10-stamp mill, and partly at Austin, in the Manhattan Mill. The Combination mill and mines have been idle. The Arizona and the northern extension of the El Dorado are spoken of as rich mines, but, so far as I am informed, work has not yet been resumed on them. The El Dorado South is described by Mr. W. F. Leon, the

agent of the company, in a recent publication in detail. I quote his account with slight alterations:

The claim is 1,000 feet lineal measurement in length, and covered by a patent from the United States Government to the present owners, making the title perfect. The property is owned by the following persons: W. F. Leon, 533⅓ feet, of which W. P. Buford has a small portion; Robert Mullen, 233⅓ feet; and C. F. Singletary, 233⅓ feet. The mining department is under the immediate supervision of Mr. Robert Mullen. As the value and importance of a mineral property depends so much or entirely upon the quantity and quality of the supply of ore, a closely detailed description of the El Dorado South lode cannot prove otherwise than interesting and acceptable to all parties engaged in mining. The deposits occur in a rather highly disturbed zone, extending in a northerly and southerly direction, with granite rocks close at hand on the west, and on the east slate and quartzite. The vein is a true fissure, and the gangue and selvage are similar in character to those of the most celebrated silver mines in Mexico, Peru, and Europe. Excepting about 250 feet at the southern extremity, the vein is plainly traceable throughout the entire property—in places by magnificent croppings, which rise three and four feet above the surface. Such outcrops are of an unusually massive character, and consist of a white, rather compact quartz, richly clouded with black and antimonial sulphurets of silver. Some of the most interesting and splendid specimens of surface silver ores are obtained from the exposed portions of the El Dorado South lode. Only a portion, however, of the vein-matter is in the solid condition represented by the prominent outcrops just described. In such solid portions of the ledge the silver most generally pervades the quartz in the form of sulphurets. Nearly the entire contents of the vein above water-level are more or less decomposed, and much of the ore occurs as chloride. The lode varies from 15 to 40 feet in width. The productive portion of the vein, the pay stratum, varies from 9 to 23 feet. It is found at times permeating the entire vein; at other times near the hanging wall. The vein has been opened at four different places along the lode for 600 feet by incline shafts and cuts. Shaft No. 1, at the northeast end, 132 feet deep; No. 2, at 80 feet south from first, 172 feet in depth; No. 3, the main incline or working shaft, 276 feet in depth, 220 feet south of No. 2; No. 4, at 300 feet from third, 60 feet deep, with cut-off 75 feet; making 640 feet of shafting.

At the depth of 240 feet in the main working shaft, at water line, a level is being run north in the solid ledge which is now in 60 feet, proving it to be over 11 feet in width, so far displaying one of the finest bodies of ore ever discovered, and impregnating the whole vein; beautiful crystallizations, including metallic silver, a combination of silver and antimony, horn silver or chloride of silver, stromeyerite, sulphuret of silver, stetefeldtite, the carbonate of copper, etc. Much of the best ore is associated with the oxides of copper and iron. In such cases the percentage of silver ore is very great, amounting at times to 25 and even 30 per cent. of the entire mass. A few assays of this body of ore have been made, varying from $53 to $1,866 per ton of 2,000 pounds.

Recent reduction of ore from the solid ledge in main shaft, at water level, yielded per ton as follows:

At Belmont Mill, 20 tons	$207 00	per ton.
At Manhattan Mill, 2 tons	860 63	"
At Manhattan Mill, 2 tons	237 00	"
At Manhattan Mill, 63 tons	220 56	"

At the south workings an enormous mass of chloride ore, colored with iron, overrides the solid lode, which has worked at the mills in this place and Austin from $130 to $562 per ton. There are now on the different dump-piles 1,000 tons of first and second class ore. That being taken out from the main shaft, and added daily to the present large amount, proves the ore in sight above water line worth alone at least a quarter of a million of dollars. The improvements on this mine in the way of shafts, levels, houses, etc., have cost over $100,000, and nothing has been done but of a useful nature. At present a whim is being used for hoisting which will be replaced by steam-hoisting works recently purchased. The engine has a capacity of thirty horse-power. The policy pursued by the owners has been rather to prospect this famous lode than to seek for profit. Already over $130,000 has been the yield of ores reduced from this property, at an average of $175 per ton. After the steam-hoisting works get in motion, sinking on the ledge will be continued for permanent work, and at certain distances in depth different levels will be run north and south the entire length of the claim. So soon as the mine is properly opened reduction works of sufficient capacity will be erected to work all classes of ore taken from the mine by the company.

The latter part of Mr. Leon's article expresses a sound policy, one which, if it had been followed by more mining companies in Nevada, would have prevented many an ignominious failure.

Mr. Canfield intends to erect a new mill furnished with a Stetefeldt

roasting furnace, at Belmont, and as soon as this is done the great mass of sixty to seventy-five dollar ore, which cannot be worked to a profit by roasting in reverberatories at Belmont, nor stand the high rates of freight to Austin to be roasted in the furnace at the Manhattan mill, will at once become available, and a great increase in the product of the district may then confidently be expected.

Montezuma district seems to be destined to become of special importance. Favorable accounts with regard to this district have reached me from time to time during the year.

The success of Messrs. McGlew & Dawley has notably contributed to the prosperity of the district at large. The first-mentioned gentleman was formerly connected with the Twin River Company as engineer, and is considered a very accomplished mechanic. The firm some time ago bought a 10-stamp mill, known as the Falkner, at Yankee Blade. With the help of fourteen laborers and two brick-masons they moved this mill to the Montezuma district, one hundred and forty miles, sawed 50,000 feet of lumber, put the mill, including three reverberatory furnaces, in running order, and had a retort of bullion ready to melt in just three months and two days. This is the quickest and most successful work ever done in the State of Nevada, in that line. The product from the 10-stamp mill of McGlew & Dawley, for the first month after its completion, was, according to advices from Austin, $20,000. Several new discoveries in the district are spoken of favorably.

Morey district was mentioned in my last report. The further developments during the last year are given in the following letter addressed to me by Mr. D. S. Ogden, the superintendent of the principal company of the district:

Agreeably to promise, I give the following statement relative to Morey district, which is mostly an extract from my report of September 1, 1870, to the company. The district is located seventy-five miles southeast of Austin, upon the eastern slope of the Hot Creek range of mountains, fifteen miles north of the village of that name. From this range there is a spur projecting in a northeasterly direction. It has a slope of 30°, terminating in a small valley.

There are apparently eighteen distinct lodes, but as the hill is penetrated by tunnels it may prove that some are the extension of others, while others may be discovered, which do not show at the surface.

These veins are within a belt of about 3,000 feet, divided into two smaller belts separated by a distance of 800 feet. They all belong to one company, and with the exception of two, upon the top of the mountain, are the only ones known in the district. They are mostly perpendicular lodes cropping out at intervals from the base of the hill to and over the summit of the mountain, a distance of 4,000 feet. The position of the veins is such that tunnels commencing at the ravine are constantly upon the veins while penetrating the hill and gaining depth from the surface, thereby saving all expenses of hoisting and pumping machinery with their attendant expenses, and giving drainage to 2,000 feet of stoping ground overhead to the summit of the mountain. Upon five of the mines considerable work has been done. The American Eagle has one incline of 90 feet, and another of 60 feet, with three levels of 60 feet. The pay ore averages one foot in width at the surface and 18 inches in the bottom of the incline. The entire ore has worked $190 per ton. The Magnolia has two inclines; one 75 feet, the other 60 feet deep. The ore at the surface was one foot wide, but at the bottom of the incline it is 2½ feet. The entire ore averages $200 per ton, but the last from the lowest depth attained worked $480 per ton. The Eureka, a parallel lode, shows from the surface to 30 feet down, the depth now attained, the same character as the last-named mine, and the ore is of the same value. The Mount Airy has a shaft 60 feet deep. The ore at the surface was one foot, but at 30 feet down is three feet wide, having entirely displaced the vein-matter. The ore has averaged only $62 per ton, though it is apparently the same vein as the Eureka. The Cedar has one tunnel commencing at the ravine, which has penetrated the hill 230 feet. Three hundred and fifty-eight feet up the hill, and 192 feet in perpendicular height from the first, there is another tunnel of 240 feet length. Still farther up the hill and 90 feet perpendicularly above the last-named tunnel there is an open cut 60 feet long, and of an average depth of 16 feet. Within this cut there is an air passage to the tunnel below. The ore from this mine has averaged $260 per ton. This is the only mine now actually worked.

The lodes referred to compose the westerly group. There has been but little done upon those composing the eastern group. The Little Giant has an open cut of 20 feet length by 8 feet depth, and a shaft of 20 feet. The ore from the mine worked $175 per ton. The Monetary has a small cut and a shaft 12 feet deep. The ore at the surface, and as low as worked, occurs in a pay streak two feet wide. No ore from this mine has been worked, but it will average from $75 to $100 per ton as per assays. The walls of all the mines are very regular and remarkably well defined, the vein-matter being from four to five feet thick. In two of the three mines, where the water line is reached, the ore has entirely displaced the vein-matter. In the other the ore is in compact quartz, which has a tinge of pink by manganese spar. It is the purpose of the present company to run three tunnels upon the line of lodes from the base of the hill, and then cross-cut the other veins. Though the ore for the last year has been teamed to Belmont, fifty miles, and to Austin, one hundred miles, by road from the mines, they have been *self-sustaining*, while being developed and improved. From the position of the lodes indicated, it is clear that a large force can be put to work in open cuts, tunneling and sinking air shafts, thereby making stoping ground rapidly, if there was a mill upon the ground to warrant it. The entire range of mountains, as far as the eye can reach, is covered with nut pine, mountain mahogany, and about three miles distant there is considerable white pine. Close by the present lower tunnel is a fine mill-site, with an abundance of water. When the mines are properly opened all the ore will pass through these tunnels to the mill, thus saving the expense of teams. The valleys are filled with bunch grass, sufficient for all the stock that may ever be required for mill and mining purposes. As the present company own all the mines thus far found, except two upon the summit of the mountain, they virtually control the whole district.

Statement of ores from Morey mines, worked from June 18 *to November* 21, 1870.

	Pounds.	Per ton.
At Hot Creek	20,000	$290
Do	28,000	198
At Austin	6,540	512
Do	2,544	289
Do	12,320	308
Do	3,538	270
Do	23,748	318
Do	1,326	196
Belmont Mill	40,000	251

The average number of miners employed from June 1, 1870, to the present time, (November,) has been five.

The total returns from Reveille district for the year ending June 1, 1870, as per census of 1870, were only $6,000, and those from the Silver Park district, according to the same source and for the same time, were $2,000. The product from all these old districts has been considerably impaired by the rush of miners to Eureka and Cope districts and to the Salt Lake country in Utah.

Mr. Stephen Roberts, the assessor of Nye County, has kindly furnished me with the following statistics:

Assessor's returns of proceeds of mines in Nye County, Nevada, for the year ending June 30, 1870.

	Tons.	Pounds.	Gross yield.
For the quarter ending September 30, 1869	121	692	$14,551 64
For the quarter ending December 31, 1869	116	1,665	19,550 37
For the quarter ending March 31, 1870	118	1,518	16,561 92
For the quarter ending June 30, 1870	444	1,503	46,400 96
Total	801	1,378	97,064 89

Advance sheets of the late census give the number of inhabitants of this county as 1,087, of whom only 6 are Chinese.

HUMBOLDT COUNTY.

I am indebted for a valuable report upon the mining operations in this county during the last year to Mr. D. Van Lennep, of Unionville. His communication, together with such other information as I have been able to obtain in regard to the Humboldt mines, is embodied in the following pages.

To the relapse during several years, which followed the first mining excitement in the county, a more healthy state of affairs and steady progress succeeded in 1870. It is now acknowledged on all sides that most of the Humboldt mines cannot be successfully developed without the aid of more or less capital. The only mines which have paid their way from the beginning have been those which, from the start, furnished a large amount of shipping ores, or, at all events, a sufficiency of rich ores to pay right along for high labor and heavy freights. Ores assaying below $200 per ton have not been, as a general thing, rich enough to be shipped to San Francisco. But since the completion of the Central Pacific the shipping business has been largely increased, and the mining interests are thus greatly indebted to the road; and on the other hand, the more facilities the railroad will extend to the mines the higher will be its own earnings through the increased developments of the mining industry.

Time has also measurably purged the mining districts of this county of that class who engaged in the business only as a speculation, and that without capital. Those remaining are more willing to earn their living and acquire wealth by hard work and by expending their surplus earnings in the further development of their claims. Humboldt County is eminently a silver-bearing region. The few gold-bearing ledges so far discovered have not given a uniform yield, but in almost all cases the precious metal was found to be very unequally distributed in the lodes. Still less gold is found in placers in the mountain gulches; and even if there were a greater supply, it probably could not be worked to advantage in most localities on account of the great scarcity of running water. In most of the mining districts the rich silver ledges have been found in limestone and calcareous slates. Galena, copper ores, sometimes rich in silver, gray antimony, and gold-bearing quartz have generally been discovered in metamorphic sandstone and slates, in trap, porphyries, etc., which frequently occur close to the limestone and calcareous slates.

In *Battle Mountain district*, the oldest camp, Battle Mountain proper, has not seen continued prosperity. The Little Giant, the first discovery in the district and the main support of the camp, is yielding little or no ore at present. Both the mine and mill were sold in the fall of 1869 to a San Francisco capitalist, and for the want of ore the mill is now run on tailings. In consequence of all this the place has declined considerably during the year. Galena, another mining camp in the district, about six miles south on the same range of mountains, has, on the contrary, been growing daily. There are several good mines in that vicinity, and it is likely to be one of the best mining camps of the county, if not of the State. Galena predominates in the ores, and is mixed with rich silver ores. Some of this ore can only be worked or reduced advantageously by smelting, while others can be worked by mill process. The Butte ledge, worked for about a year by the first locators, has yielded sufficient shipping ore to enable the owners to keep a body of twenty to thirty miners constantly at work. The mine was thus opened to great advantage, exposing many thousand tons of ore. In the month of December it was sold to a San Francisco company, together with a large

amount of milling ore on the dumps, for $75,000. The buyers are making the necessary arrangements to build a 30-stamp mill a short distance from the mine. The "White" ledge yields also good ores of silver and lead, and the owners will undoubtedly realize handsome profits. A steam-pump was placed at this mine last summer, on account of the vast increase of water in the works. The Avalanch yields rich galena. The water and limited means of the owners are the obstacles to its immediate development. The Shiloh is also a rich galena mine, but it has been stopped on account of water and the small means of the owners. The Buena Vista ledge has not yet proved a success. There are many other claims which will come to the notice of the public as soon as the necessary work is performed on them. In the same district, about two miles south of Galena, is another camp called Copper Cañon, in which are found good copper mines, bearing carbonates, oxides, native copper, etc. One of them is owned by an English company. The ores are shipped at present to San Francisco. They contain a small amount of silver.

There has been an attempt to run a smelting furnace on Duck Creek, the stream coming out of Galena Cañon, but it has so far been a failure. The camp is yet too young to furnish the steady supply of ore necessary to run a furnace profitably.

The Trenton ledge is also in Battle Mountain district; it is situated about seven miles northwest of Galena on the western slope, or rather in one of the western cañons of the same range. Battle Mountain, Galena, and Copper Cañon are all in the cañons cutting the range on its eastern slope. The Trenton has been worked for several months, and a considerable amount of ore is now out. In the month of December the company owning the mine have purchased one of the mills of Gold Run district called Holt's mill, and have erected the same about six miles from their mine. It was expected to commence working the rock in the beginning of the year 1871. It has four stamps and two pans.

In *Gold Run district*, the Golconda mine was worked until about the beginning of April, when, on account of the low-grade ores taken from the levels worked, it was discontinued, and has been idle ever since. The mine has been worked only to a depth of about 30 feet below the level of the tunnel. The amount of water at that depth requires a steam pump to overcome it, and the company do not seem to consider it advisable to put this up at present. There is a good chance of getting richer rock lower down, for the ledge diminishes in size, and the pay streaks are more concentrated. In the upper portion it is from 7 to 8 feet wide. The mill of the Golconda mine was worked mostly on tailings in the winter months and until the middle of spring. The ore is decomposed and contains lead and silver. It has been worked by the mill to nearly 50 per cent. of the assay value.

On the second extension of the Golconda mine, work has been done last fall. About 200 tons of ore have been extracted, and the Golconda mill, a water-wheel mill, was to have reduced the ore. It is now reported that the ore is too poor to bear the expense of working and transportation.

Besides the above-named ledge, the Jefferson, the Cumberland, and others, have been worked considerably in the above-mentioned district, but until now the mineral has been too poor to bear the expenses of extraction, milling, and transportation.

In *Central district*, on the eastern side of the mountain forming the district, two persevering miners have worked a ledge during the year, and with a small prospecting mill have reduced enough to pay for their trouble and expenses.

In the fall another ledge, with a narrow streak of rich mineral, was found and worked. The ore is sent by rail to San Francisco.

In *Echo district*, situated south of Humboldt district, the Alpha mine, owned by an English company, has been worked but little during the year. The ledge seems to have given out, and further prospecting has been carried on under a disadvantage on account of too much water in the mine. The extension of the Alpha, owned by the original locators of the Alpha, has been worked with much success, and a great deal of mineral was extracted. The richest portion was and is now shipped to San Francisco, and the poorest, or milling ore, is ready at the mine to be worked by a mill just erected near the Rye Patch Station, Central Pacific Railroad, which is about three miles from the mine. This mill depends for its supply of water on a well sunk near the mill. It has ten stamps, but only five have been put up. The pans are rimmed with wood, to avoid the action of iron on the chemicals. The ore is dry-crushed, then carried to a second story of the building, and dropped through fire in a furnace which works on the same principle as the Stetefeldt furnace. After this it is worked in the pans. The result is not yet known, the work going on at the present hour.

In *Santa Clara district*, lying on the eastern slope of the Humboldt range, (it is northeast of Star Peak, and bounded on the south by Star district,) an old ledge has been taken up and worked a good portion of the year without any marked success.

Star district.—The De Soto has been worked most of the summer and fall by a few hands, extracting all accessible shipping ore for the San Francisco market, and laying the poorer quality by for future concentration. This work was principally done with a view of prospecting the mine. Last summer the owners of the Sheba mine made arrangements with J. C. Fall & Co., of Unionville, to work the mine and concentrate the ore found on the dump, as an overshot water-wheel was constructed a few hundred feet below the dump, and five stamps were erected, with sluices, etc., for concentration. It was run for a few days, but before everything could be arranged for a successful working the supply of water in the cañon diminished so much that the wheel could not be run. It will be put in running order with the increase of the water in the spring. The mine has been steadily worked by a small force all summer and fall, and regular shipments of the richest part of the ledge have been effected. The mine has been perseveringly prospected. The ledge on the western side of the main tunnel had been lost, being here displaced by a cross-course cutting it diagonally. The cross-course was followed last summer for about 200 feet, when casings with quartz were reached to the west of it. These casings were again followed about 100 feet, when a large body of quartz was found, bearing much rich mineral. It seems yet uncertain whether this is the continuation of the old ledge or merely a deposit of mineral. However that may be, the perseverance and faith of the managers have been well compensated by the rich discovery. In the same district, in a cañon south of Star Cañon, two ledges of gray antimony have been worked in November and December, and the mineral shipped to San Francisco in small quantities. It is thought to pay the owners a few dollars per ton profit.

In *Buena Vista district* the point of all-absorbing interest during the year has been the law-suit and final compromise of the two mines of the Arizona and Silver Co.'s, which lie in close proximity to each other. The quarrel began last year, during the fall, and a receiver was appointed by the court to account for and take charge of the ore coming out of the ground in dispute. Unionville, the county-seat, being in this

district, and only about a mile from the mines spoken of, it was easier for the contending parties to have the matter examined by the judge, the jurymen, etc., than if otherwise situated. The main point in the case was to ascertain whether the two mines found in the hill are on one and the same ledge, or on two different ledges crossing each other. The suit came off last spring, and a verdict was given in favor of the two-ledge theory. The case was appealed, and the contending parties, after divers and vexatious expenses, hard feelings toward each other, and bad forebodings as to the final result, with which a long list of legal expenses, running high on this coast, was surely connected, determined at last, very wisely, to compromise the suit by consolidation. This was effected in October, and since then the lost time has been redeemed by greater activity, which has been rewarded by the extraction of a larger amount of rich ore than the mines ever yielded before.

The ledges thus far have been worked for about 70 feet perpendicularly below the outcrops. Below this depth the quartz has given out; the walls are yet discernible, but have not been followed. The foot-wall is black limestone and calcareous slates, in some parts of which are found ammonites. The most westerly ledge, running a little east of south, has been followed into the hill, until the present time, for about 550 feet on its course, and it bears uniformly good mineral, mixed with rich shipping ore. The easterly ledge runs nearly southeast, and has been followed for about 400 feet, 300 feet of which bear good mineral, and in places large spots of shipping ores. The last 100 feet were run in broken ground, in which the little mineral was all much scattered. Some work done last month on one side of the tunnel gives some hopes of finding the solid ledge again.

The owners stoped out much ground last summer and fall. At present and during the rest of the winter the mine will be put in shape to extract a large amount of ore as soon as fine weather sets in.

The Manitowoc mine, a mine adjoining the two mentioned above, has been worked out during the year. Work was discontinued at the end of summer. It is a nearly flat ledge, which has been followed into the hill about 200 feet, where it thinned out to a mere thread, and was abandoned. It belongs to Fall & Temple.

The amount of rock which came out of the Fall & Temple mines during the first nine and a half months of the year, *i. e.*, until the compromise was made, is 5,233 tons. The rock taken out of the Silver Mining Company's mine during the same time is 1,421 tons. The rock raised since the compromise to the end of the year, *i. e.*, from October 10 to December 31, is 2,492 tons. Total from the three mines during the year, 9,146 tons.

The three mills, the Pioneer, the Arizona, and the Silver Mining Company's mill, have run mostly on Arizona and Manitowoc ores during the year. The Pioneer Mill was renovated and enlarged in the beginning of the year 1870. To the old water-wheel a small engine was added as motive power. The eight old pans were replaced by three large ones of Wheeler's pattern. A new boiler was put up, and a fine battery of ten stamps completes the renovation. It has crushed since the change was effected about 2,600 tons of rock, and many hundred tons of tailings have been passed through the pans besides. The Arizona Mill has crushed not far from 3,500 tons. The Silver Mining Company's mill was stopped for a considerable time during the summer for want of rock and for repairs. It has now a battery of ten stamps and three large pans, and has worked about 2,000 tons of rock, besides many tons of tailings.

I am unable to give the shipment of bullion from Unionville in detail,

but I have taken careful notes of the shipments from the books of the two firms that have sent the most to San Francisco, viz:

Sent by J. C. Fall & Co. until the middle of October, actual value		$170,895 94
By the Silver Mining Company, value about		52,300 00
By both firms for the second half of October,	{ $10,703 94 8,609 02 }	19,312 96
In November		16,582 96
In December		32,641 08
Total during 1870		291,732 94

The old Inskip ledge and the North Star have been worked steadily all summer and fall for account of a New York company—the Pioneer and Inskip. The two mines are close together, and are supposed to be on the same ledge; they lie about half a mile southwest of the Arizona mines. The country rock in which the ledges are found is calcareous slate, which is apparently cut through in two different places by parallel dikes of porphyry. This eruptive rock has disturbed the ground much. In the Inskip the ledge has been persistently followed in all its freaks, but thus far the rich mineral has only been found in bunches. Work has been stopped at present in this mine. On the North Star ground, cut already by several old works, prospecting was carried on on various seams until a wide ledge was found with paying mineral. This was followed until another smaller ledge was reached joining the first, and also bearing good mineral. From these quite a large quantity of quartz has been removed, and they are still yielding without any falling off. The rock taken out of the two mines and hauled to the Pioneer Mill amounts, to December 31, to 231 tons; of this about seven tons of shipping ore have been picked and sent to San Francisco for sale. They yielded about $350 per ton, net. The ore has much lead in it, and produces very base bullion by mill process.

The Potosi ledge is about a mile south of the North Star, on the same belt. A good deal of work has been done on it. Now some miners have a contract to run an adit of 50 feet on the ledge, which shows quartz spotted with mineral.

During the summer and fall the Crystal ledge, located near the summit of the main range, at the head of Wilson Cañon, about four miles from Unionville, and west of the Arizona ledge, has been worked in a small way with constancy and perseverance by the discoverers. Shipping ore has been taken out to pay, probably, for all the work done; but the inaccessible situation of the claim has, up to the present, prevented the shipment of the same. The claim lies in limestone. Its high position on the mountains prevents working in the winter.

The Eclipse, another claim, has been worked by two of the owners during the year. It is in Eagle Cañon, and about three miles west of Unionville. Shipping ore has been sent to San Francisco, and said to have netted about $130 to the ton.

The Seminole ledge, owned by an eastern company, was visited last spring by two of the principal owners. It is situated about a quarter of a mile west of the upper town of Unionville. The company have run a tunnel of over 600 feet in length into the hill to reach the ledge, the outcrop of which is found high up on the hill, northwest of the tunnel. The latter having been run considerably beyond the point where the ledge was expected to cross its course, it was deemed advisable to

follow the outcrop above mentioned along the hill to a point right above the tunnel. But this was found to be impracticable without a heavy outlay, as the ground was disturbed on the line of the ledge, between the outcrop and the line of the tunnel. At this crisis the owners had about three tons taken out of a small shaft sunk on the outcrop of the ledge, which was crushed and amalgamated in the battery to take up the gold found in the rock. The bullion, pulp, and tailings were tested by assay. The result seems to have been unfavorable, and since then the work has been entirely stopped. The belief of the value of the mine had been based on assays made of specimens taken out of the shaft on the outcrop. But, as is too often the case, these people deceived themselves very innocently by supposing that a specimen is a criterion of the value of a mine.

The prospecting done in *Indian district*, lying south of Buena Vista, has not resulted in any valuable discovery.

In *Sacramento district*, the Batavia Company placed steam hoisting-works on the Rochester shaft and considerable work was performed on the mine. But the drift run from the shaft to strike the ledge having failed to find any paying quartz, the work was discontinued. The president of the company visited the country with an enterprising stockholder and made arrangements to explore a claim found in the vicinity of the Rochester mine. This was also abandoned because the company finally purchased the Central Pacific mine, in Relief district, about ten miles east of the Rochester.

Relief district was organized at the end of 1869 or the beginning of 1870. It is about twenty-five miles a little west of south of Unionville. The Humboldt range in approaching the Humboldt Sink divides into two branches, one extending west of the sink and the other northeast. Relief district comprises a portion of the last-mentioned hills. The formations of limestones, metamorphic sandstones, and traps are very distinctly recognized already at a distance from these hills. The ledges found there occur between the strata of the different rocks and run with them. Many claims have been located, but as yet only the Central Pacific ledge has been worked enough to test its value. The discoverer has worked it successfully by shipping to San Francisco or Reno the richest portion of the ore. His partners, however, having brought a lawsuit against him, the larger portion of the mine was sold to the Batavia Company, an eastern company, at a low figure. The Batavia have worked the mine until recently. There being over a thousand tons of rock on the dump, work was discontinued for the present. Two or three shipments of ore were made by the company, and the report is that a ten-stamp mill will be erected in the cañon in 1871; in fact, one of the leading members of the company is daily expected on the spot to make the necessary arrangements for construction. The mine is about seventeen miles from Oreana, a station on the Central Pacific Railroad.

I am not aware of the causes that have changed the former activity in *Trinity district* into the present stagnation; but the few facts that I know may be stated here, together with the general transactions during the year. The mines had been idle for many months, and the works at Oreana shut down and attached by the creditors of the Montezuma Company, when, last February, after the term allowed by law for sale had expired, the works of the Montezuma Company were bought by a San Francisco capitalist. It is reported that Toomey & Mossheimer rented the works from the owners for a number of years. Mr. Mossheimer went to Oreana, made many repairs, and bought in the tools belonging to the works and which had been in the hands of the creditors.

of the Montezuma Company. He thus spent several thousand dollars. He had a good deal of rock on hand, and made three or four attempts to run the smelting furnace, but failed to succeed in smelting the rock properly; each time the furnace cooled and had to be torn down at the hearth and repaired. After this Mr. Drake, it is reported, rented the works. Drake worked successfully for about a month, and shipped by railroad about 25 tons of metal to San Francisco, and from there it was sent to Swansea. He got, it is said, $90 per ton in advance, but having little capital, and not being able to dispose of the metal immediately, had to close the works for want of means.

Mr. Strout also made an attempt at smelting. He leased the Savannah mine and built a furnace. The furnace was too large at first; then the tuyère was too small. He made two runs with partial success, and being without capital could not meet the demands of his creditors. The Savannah mine gave out in the portion he was at work on, and this made his situation still less tenable.

Mr. Torrey, who in early days had built some works at Etna, about three miles on the Humboldt River above Oreana, and which had fallen into the hands of creditors at the time, went this summer to the spot, repaired the works, built a water-wheel on the river, and connected his machinery with it. The works are said to be constructed so as to work economically. He made, however, two different attempts at smelting, but failed, and his workmen all became sick from the antimonial fumes. He is still at work on tailings in a mill connected with the works, I am told.

It will be conceded by people conversant with the mining interests of Humboldt County that smelting works on the Humboldt River, properly and economically built, erected and run by men of experience who understand the business, would be very desirable. They would save much transportation, give employment to many in the county, and be a source of revenue to the county and the owners.

Much capital is needed for such an enterprise, in order to secure the greatest economy in smelting, buying of ores, &c. A formidable obstacle is, however, the scarcity of fuel; but this may be overcome in time by new discoveries of coal and cheaper means of transportation by railroads. Coal from the Wahsatch Mountains, near the line of the Union Pacific Railroad, is now delivered at Mill City for $13 per ton. This is likely soon to take the place of wood in all places near the line of the railroad.

During the last year the bullion returns are no criterion for the product of the mines of Humboldt County, a great deal of ore having been shipped to different places for reduction outside of the county. The works at Reno, using the Stetefeldt furnace, and guaranteeing 8[illegible] per cent. of the assay value to customers, have reduced considerable mineral rich enough to bear the expense of transportation, bagging, and milling. It has also been the practice of miners to send to the same works a few tons at a time to test their rock. Others, again, sell their rich ores at San Francisco to the smelting works, or to English and eastern agents for further shipment; while others, again, obtain advances and ship to Swansea direct for sale on commission. This is done for all kinds of minerals that are valuable enough to bear the incidental expenses.

I have obtained a statement of ore shipments made from this place. It comprises almost all the rich ore shipped. There were a few small lots sent out on trial which I could not obtain, but they would not materially alter the total.

Shipped by J. C. Fall & Co., about 100 tons, yielding net in round figures	$33,500
Shipped by the Silver Mining Company to the month of October, about 44 tons	15,300
Shipped by the Arizona Association during the months of October, November, aud December, 80 tons	30,000
Total	78,800

These were ores containing lead, antimony, and sometimes copper aud iron, besides the silver.

The difficulty of reducing properly the silver ores of Humboldt County by the raw Washoe method compels the shipment of all rich ores out of the county for reduction in such places where it can be done more thoroughly. The advantages of the Stetefeldt furnace are not yet understood, and the expenses of construction, of buying the right to use it, and the paying of the royalty, as well as the prejudice against new inventions, are obstacles in the way of its getting into general use. By the Washoe method from 30 to 50 per cent. of the assay value are obtained, according to the character of the ores and the experience of the amalgamators. In Virginia City not much more is obtained of the silver in the ore, but those ores having a good percentage of gold, which is worked up to 90 per cent. of assay value by the method, it increases the proportion of the yield of the whole rock.

The advance in the price of quicksilver by speculation at San Francisco is very detrimental to the mining interests of this coast. In Humboldt County it amounts to 30 cents to the pound.

Cost of mining and reducing ores in Buena Vista district, Humboldt County, Nevada.—Population, 500. Wages of first-class miners, $4, or $3 and board, per day; wages of surface laborers, $2 50 and board, or $3 50, per day. Cost of lumber per M, $36 to $40; cost of mining timber, $36 to $40; cost of common powder, $4 to $4 50; cost of giant-powder, $1 25 per pound, used very little; cost of quicksilver, 62½ to 70 cents, increased lately to 92½ cents, per pound; cost of freight from base of supplies, $40 per ton. Cost of fuel: cedar wood, $12; mountain mahogany, $15; stone-coal, from $20 to $25. Average mining cost per ton, $8 to $15; average milling cost per ton, $10 to $12; average pulp assays of ore, $60 to $90; average yield of ore, $25 to $40.

Remarks.—Indians are paid from $1 50 to $2 50 per day; Chinamen, in and about the mills, for wheeling tailings, &c., $1 50; for firing furnace, $2, boarding themselves. White men in the mills: engineer, $4 and board; panman, from $2 50 to $3 and board; for assorting rock, $2 50 and board. This year common laborers are more abundant, and can be had frequently at lower rates.

In the Arizona mine sawed timber from the Sierras is used, coming here at about $36. It is for sale here at the lumber yard at $40.

Giant-powder is only used in open cuts, and where a single man is at work; also for very wet ground. The use thus far is very limited.

Freight has been reduced during the year. For shipping back freight to San Francisco it is a great deal cheaper, and often $11, and even $10, per ton, if special contract is made for a large quantity.

Stone-coal is hardly used; so far only, I believe, for blacksmithing. A trial to burn it in one of the mills has failed. It can be had by the quantity at about $20; in small lots, at $25.

At the Arizona mine the mining has probably cost this year about $8 per ton. In smaller mines the cost goes as high as $15 per ton.

The following information about mining operations in the *Sierra* and *Oro Fino districts* was obtained mostly from Mr. Charles D. Smith, who is in charge of the Monroe mine, near Dun Glen, in Sierra district, and transmitted to me by Mr. Van Lennep:

The Oro Fino district is now merged into the Sierra district.

The Monroe mine has had little work done on it last year. The mine has fallen into the hands of some of the former owners, and will likely be worked in 1871.

The Tallulah mine is about two miles northwest of Dun Glen, and has been worked during the year by driving a tunnel to reach the ledge at about 50 feet below the former tunnel. This lower tunnel is now about 400 feet in the hill. The rock has been exceedingly hard, and at times flinty, increasing a great deal the cost of the tunnel. Two silver-bearing quartz ledges have been intersected on its course, which had not been looked for. They are of a similar character as the ledges worked heretofore in the upper works. Another ledge is soon expected to be reached; its outcrop is found on the surface. The ledges bear silver sulphurets, mixed with base metals, such as zinc blende, copper pyrites, and iron pyrites. In 1869, when the company worked the mine in the upper works, the rich part of the mineral was selected and shipped to San Francisco.

About a mile southeast of the Tallulah is the Empire mine, now abandoned for over two years. Mr. J. C. Fall, of Unionville, who owns the mine, commenced work on it last fall. Some places in the ledge have been found to contain pockets of rich mineral. There is nothing permanent as yet.

About two miles northeast of Dun Glen a new claim, called the Auburn, was prospected during the fall, and nearly five tons of ore were worked at the Essex Mill, yielding about $50 per ton in gold. It was not worked for silver. The ledge is small. There are at present several tons of ore on the dump. It is near the Alaska, worked last year extensively by the same party.

From the Ne Plus Ultra some ore was shipped to San Francisco, yielding $149 per ton. The ore consists of silver and base-metal sulphurets.

In Barber's Cañon, about four miles east of Dun Glen, the Franklin ledge has been prospected. The ore is argentiferous galena, with gold.

On the Old Lang Syne mine work has been going on since last fall. It shows a large body of white quartz, with free gold and some sulphurets.

In the old *Oro Fino district* two new discoveries are claimed. The Good Samaritan, on the dump of which a large lot of ore has accumulated, contains gold, galena, and silver. It is said to yield, on an average, $100 per ton. Northeast of the Good Samaritan another ledge is being prospected by an incline. The ore taken out contains silver, lead, and gold, the latter being diffused throughout the quartz.

In the northwestern part of Sierra district a silver-bearing ledge, called Coin, has been discovered. It is about three miles from the Central Pacific Railroad. Its true merits are not yet known.

In general, there is a better inclination and disposition among owners of claims and mines in this district to spend money and labor, as far as their means go, to work their property, and thus to develop the resources of the country; but the capital at their disposal is small, and, in most cases, not sufficient for the task undertaken by them.

The latest information which I have in regard to mining affairs of

Humboldt County reaches up to the end of February, 1871. My correspondent writes from Unionville:

In Buena Vista mining district, in which this town is situated, the prospects of general and greater activity in mining are confirmed by the preparations with the approach of spring. The three mills have kept at work all winter. The Silver Mining Company's mill and the Arizona Mill have been running on Arizona ore, of which a stock had accumulated at each mill before the winter set in. The Pioneer, after having been idle a few weeks to repair the water-wheel, has been running on North Star rock a few days, and then on old tailings, on account of scarcity of water in the creek. The Arizona mine has been worked regularly since the first of the year with a force of about twenty miners. Only the shipping rock is brought down, assorted, and shipped to California. The North Star mine is worked by a force of about ten miners, taking out the lower-grade rock for milling and the usual percentage of shipping ores. The ledge is yet irregular and broken, having been opened only a few feet from the surface. The Potosi tunnel is being run steadily by two men on contract. Three or four other claims wait for the fine weather to set in, to be worked. It is understood that the force of miners will be increased in the Arizona and North Star mines as soon as regular hauling is practicable.

Central district is drawing considerable attention, there being three ledges now worked by the locators. These ledges are rich enough to pay the owners a profit by shipping the rock to Reno or San Francisco for reduction. It is expected that the Ruth Mill at Rye Patch will soon commence working custom rock. This will be a great advantage to the mines in the vicinity, giving them a chance to work such ores as would be too poor to ship to Reno and elsewhere. The Aikin furnace connected with the mill, said to be an infringement on the Stetefeldt furnace, has been visited by the partner of Mr. Stetefeldt, who is reported to have brought the necessary papers to stop the work; but on examination he went away without serving them. Mr. Aikin has also been in town.

Star district will probably draw attention during the next summer. Both the Sheba and the De Soto have struck rich bodies of ore, and it is said that active operations will begin as soon as there is sufficient water in the cañon to start the stamps and concentrating machinery put up last fall. Mr. Osbeston, the manager of the Reno Mill, has visited the Whitmore Company's claim, Sheba series, a claim owned by his company near the De Soto, and was so far pleased with the outcrop as to contemplate active operations the coming season. Besides these there are other claims on which considerable work has been done, which are likely to resume work as soon as hopeful indications are found in the district.

In this district (Buena Vista) in Bloody Cañon two antimony ledges are worked, and about twenty tons have been shipped to San Francisco for sale. With a little more encouragement much gray antimony and copper ore would find their way to the markets of the world from many districts of this county. At Oreana all the smelting works have stopped work. Mr. Torrey, who has an undershot water-wheel on the Humboldt River, about three miles north of Oreana, with which he runs a few pans and the blast of a furnace, is yet at work trying to beneficiate the ores of the district. He is trying to introduce the metal smelted out in his furnace as Babbit metal. It is said to have answered the purposes for which this metal is used, where tried. Antimony and lead are said to be the principal constituents of his product, while iron and silver are present in very small quantities only.

The late census gives the number of inhabitants of Humboldt County as 1,916; 219 of these are Chinese.

Movement of ores and base bullion.—The Sacramento Reporter furnishes the following interesting information on this head:

The report of the State mineralogist of Nevada for the two years ending with 1870 gives statistics showing the amount of ores and metal shipped from Eastern Nevada by railroad in 1869 and 1870. The figures for 1870 close with the month of November. During the entire period it is worthy of note that only 3,885 pounds of ore were shipped eastward. The shipment of ores to California during the two years was as follows:

	1869. Pounds.	1870. Pounds.
January	12,186	764,707
February	14,796	404,788
March	36,000	797,641
April	299,266	1,018,303
May	100,848	919,327
June	178,656	960,262
July	173,010	1,364,190
August	182,717	1,280,845

	1869. Pounds.	1870. Pounds.
September	245,620	897,182
October	352,037	2,066,771
November	724,837	1,556,593
December	627,562	....
Total	2,947,535	12,030,609

These figures show two interesting facts: First that about all the ores shipped from Eastern Nevada for reduction comes to California, either to be worked in San Francisco, or to be shipped thence to England. The largest portion of the ores have been shipped from this country at a cost of about $12 a ton for freight and handling, after reaching San Francisco. The other fact is that the increase in the yield of the mines of Eastern Nevada since the opening of the railroad, and the consequent facilities for shipment, has been nearly 600 per cent. In fact, scarcely any of the mines in that region could have been worked without the facilities for getting the ores to market afforded by the railroad. It will be seen that in twenty-three months 9,489 tons of ore were shipped. This ore was worth on an average at least $100 per ton, or in the aggregate $948,900.

In addition to the above, there was shipped from Eastern Nevada metal (lead and silver extracted from base-metal ores) as follows, in 1870:

	Ship'd West. Pounds.	Ship'd East. Pounds.
January	119,247	....
February	320,651	....
March	182,782	225,937
April	92,257	336,794
May	191,346	382,807
June	278,246	920,303
July	307,967	777,340
August	582,700	477,243
September	446,490	62,183
October	309,728	482,994
November	974,070	263,828
In 1869	102,485	....
Total	3,907,969	3,929,431

Here we have 3,918¼ tons of metal shipped last year, worth about $250 per ton on the average, and in the aggregate, $979,625. The production of metal did not commence until the latter part of 1869, and that, as well as the shipment of ores, could not have been attempted without railroad facilities. The increase in the shipment of metals, it will be seen, has been great, going from 119,247 pounds in January up to over 1,200,000 pounds in November. It will also be noticed that while the shipments in this direction have been constantly on the increase, shipments to the east since June have been diminishing, showing the cheapest and favorite route of shipment to be toward the Pacific coast.

We have no means at hand of knowing the amount of pure bullion shipped from Eastern Nevada since January 1869. That probably would have been about the same had there been no railroad, so that the railroad has increased the yield of the mines in twenty-three months to the amount of ores and metal shipped, as follows:

Value of ore shipped	$948,900
Value of metal shipped	979,625
Total	1,928,525

Or, in round numbers, $2,000,000 added to the real wealth of the country, and the production increasing at the rate of from 300 to 400 per cent. per annum.

The following statement, prepared by Mr. A. D. Hodges, jr., of San Francisco, differs somewhat from the estimates of the Nevada State mineralogist. Mr. Hodges writes me with regard to his statistics as follows, January 17, 1871:

"The statistics were obtained from the cargoes as *received* in this city, (not as per invoice,) and any wastage must, therefore, be added. Again,

as the returns are partly made in sacks of ore and bars of bullion, it has been necessary to reduce these to tons. Up to September, in fact, all ore and bullion were thus given me; but since then I have obtained the weights of all interior shipments. In reducing to tons, I visited shipping places and took the average of large shipments. I find that the bars of bullion will average about 100 pounds, (the average of several thousand tons.) The ore sacks from the southern country average the same (100 pounds) and are reckoned as such, while 90 pounds is the weight taken per sack of interior ores, as the sacks from Utah are smaller than the others and thus bring down the average. I give you these particulars as you may consider them essential.

"My statistics commence in October 15, 1869. I therefore add the following for the rest of that year."

1869.	Ore-sacks.		Bullion-bars.	
	Interior.	South.	Interior.	South.
October 15–31	2,357	21	....	....
November	3,817	....	158	....
December	3,291	198	66	1,189

Here is Mr. Hodges's table for 1870, published January 7, 1871, in the Scientific Press. It includes the receipts at San Francisco from the East and South. The columns headed "Interior" give the amounts received over the railroad; those headed "South," the amounts from the southern country:

	ORE.				BULLION.			
	Interior.		South.		Interior.		South.	
	Tons.	*Lbs.*	*Tons.*	*Lbs.*	*Tons.*	*Lbs.*	*Tons.*	*Lbs.*
January	109	1,660	4	400	....	....	46	900
February	109	250	......	....	....	....	47	1,500
March	119	320	19	200	45	1,000	25	1,000
April	219	300	22	700	57	700	40	700
May	308	320	40	1,400	58	400	63	1,500
June	268	1,390	20	300	119	200	48	1,000
July	523	1,960	4	100	131	600	113	400
August	571	190	64	1,400	289	1,900	46	800
September	318	110	18	700	144	500	36	600
October	797	700	3	300	86	900	137	1,400
November	750	900	48	1,500	425	1,300	......	....
December	882	500	2	500	328	1,200	118	500
	4,537	600	247	1,500	1,681	700	724	300
Totals	4,785 tons 100 lbs.				2,405 tons 1,000 lbs.			

Average per month: Ore, 398 tons 1,503⅓ lbs; bullion, 200 tons 916⅔ lbs.

If we calculate that there are three hundred working days, for smelting works, in the year, (which number is in excess of the reality,) we have an average of nearly 18 tons of ore and over 8 tons in bullion per working day, for the year. But this average does not give a fair representation of the existing state of affairs, for the smaller shipments at the beginning of the year bring down the average. A fairer idea will be

given by taking the average of the four quarters of the year, with seventy-five working days in each quarter. We have then—

	Ore.		Bullion.	
	Tons,	pounds.	Tons,	pounds.
January to March	5	1,238	2	405
April to June	11	1,445	5	327
July to September	20	54	19	304
October to December	26	912	14	1,111

The circumstance of the most interest and importance connected with these figures is the increase. That this increase has been due in great measure to the present smelting works of San Francisco cannot be doubted, and it is reasonable to suppose that increased facilities will bring still greater supplies.

An account of the works referred to is given elsewhere in this report.

ELKO COUNTY.

Several new mining districts discovered and organized north of the Central Pacific Railroad have attracted much attention. The most prominent one is Cope district, which was mentioned in my last report. Bull Run and Bruno districts are the newest, and, as far as known, both promise to become of some importance.

Cope district has furnished considerable bullion during the year. My correspondent, writing from Mountain City, in the latter part of August, gives the following information:

This city is located on the Owyhee River eighty-five miles north from Elko, on the Central Pacific Railroad. It is now a trifle over one year old, has about two hundred buildings, among which are to be found specimens of cloth, adobe, log, frame, and cut stone, and the hammer and saw are to be heard on every side. The population, including Chinese and a few Indians, is not far from 1,000. Cope district, of which Mountain City is the metropolis, is chiefly remarkable as presenting a case of modest merit, something exceedingly rare in these days of shams and false pretenses. Her miners, instead of making coyote holes in the hillsides, and then sitting down by them to wait for capital, very sensibly rolled up their sleeves and went to work. Ores were shipped to Reno and other points, at an average expense of $100 a ton for freight and milling, that netted the owners from $50 to $300. The results were expended in further developments, and to-day there are few places in the State that can show a more inviting field for capital or energy and ability than Cope. Late last fall a ten-stamp mill was put up by Atchinson, Drew & Co., and has been running steadily ever since, principally on Argenta and Crescent ores. Colonel Drew is the superintendent. Messrs. Norton & Co. are erecting a thirteen-stamp mill, under Mr. Turner's superintendence, below the town. They are pushing the work with energy, and expect to be ready for crushing by October 1st. I learn that the Argenta Company will supply it with ore. Three-fourths of a mile above town, R. H. Vance is building one of his "Little Giant" mills. The ore is pulverized by the action of rollers on a revolving bed-plate. The mill will have, it is calculated, a capacity for crushing twelve tons daily. The invention has not yet been tested here, I believe; but there is one in operation in San Francisco that is said to be a perfect success. This mill is to work on ore from the Mountain City mine on contract. Report says that Wallbridge & Co., of Idaho, are going to put a five-stamp mill on the Monitor mine; so there will be thirty-five at all events, and probably forty stamps, in operation this winter—a pretty good showing for a district one year old, and that has paddled its own canoe from the start. The facilities for mining here are above the average. The climate is mild; snow is never troublesome; wood is abundant within from seven to ten miles; excellent water everywhere; plenty of good pasturage; stock will thrive without feeding the year round; and the mines, being located on low foot-hills 50 to 200 feet above the valley, are easy of access, and can be advantageously worked in winter as well as summer.

The mines are located in the immediate vicinity of town, on both sides of the river. As far as surface indications go, the quartz veins of Cope will compare favorably with any other mining camp, but none of the ledges have yet been worked to a sufficient depth to establish their permanence beyond a doubt. The ores are principally true silver ores and remarkably free of the baser metals. A claim consists of 200 feet, upon which two days' work must be done within sixty days after location, and two days more before the expiration of a year. The principal ledges are from a foot and a half

to four feet in width, and approach a horizontal position, many of them having an angle of 40°. While there has been only one mill in the district, there have been only about twenty men at work taking out ore, but many more will be employed as soon as the two new mills are ready to operate. The Columbia Company have struck the eastern extension of the Argenta, 1,400 feet from the discovery shaft, demonstrating the fact that the ledges of Cope have some length as well as width and depth. John A. Lyttle & Co. have traced the Nevada ledge down the side of California Hill, and are running in a tunnel on the vein, which is said to be large and rich. Cutler & Co. are sinking on the Crown Point, opposite Dye's store, in Placerville, and are taking out some fine-looking ore. The Argenta and Crescent have been worked some distance below the water-level, and show black sulphurets in abundance. The Buckeye, owned by Cope & Co., shows a large and well-defined ledge on the surface, but has not been worked to any depth. The Monitor, situated near the Crescent, is one of the most promising ledges in camp. It is five feet wide, and will probably yield $50 or $60 per ton.

So far the mines have been easily worked, the gangue being as yet comparatively soft at the depth reached in most mines. The developments of the district progressed favorably throughout the year, and in the fall the Crescent Company had 210 tons of ore worked at the Atchison or Drew Mill, which gave an average yield of $234 per ton, falling much below the expectations based on assays. The Crown Point (Cutler & Co.) had a shaft down 25 feet, in a large body of ore, milling $100 to the ton and upward. Fuller & Ferguson had commenced work on the Great Eastern, with good prospects, the ore assaying from $250 to $300 to the ton. The Ada Gossage, located one mile and a half from Mountain City, and owned by Henry, Velt, Upton & Frederick Brothers, had a shaft 70 feet deep, and ore assaying from $300 to $500 to the ton. The Argenta, Argenta Excelsior, and Argenta Extension were all looking well. The Sunny Hill, three miles southeast of town, Keystone, and Virginia were being actively worked and looked well. The Mountain City Silver Mining Company (Oppenheimer, Hart, and others) had out a large quantity of good ore, which was to be crushed as soon as the Vance Mill would be in readiness. Placer-mining by Chinamen, on the north side of the river, was going on actively, but water was scarce. The Chinamen made from two to three dollars per day, but competent judges, who have examined the ground, believe that if water were plenty the mines could be made to pay $10 per day to the man.

Name.	Owner.	Character.	Course.	Dip.	Dimensions of claim. Width.	Dimensions of claim. Length.	Country rock.	Vein matter.	Ore.	Value per ton.
				°						
Argenta	Argenta Gold and Silver Mining Company	Lode	N. & S.	45	3 feet	1,400 feet	Granite	Quartz	Sulphuret of silver is worked raw.	$150
Excelsior	Dixon, Riely, Cope & Co	Lode	N. & S.	45	3½ feet	1,400 feet	Granite	Quartz		60
Crescent	Carter, Cage & Co	Lode	N. & S.	45	2 feet	1,000 feet	Granite	Quartz		50
Monitor	Wallbridge & Co	Lode	N. & S.	50	2½ feet	1,000 feet	Granite	Quartz		80
Buckeye	Cope & Co	Lode	N. & S.	30	....	1,400 feet	Granite	Quartz		55
California	Lyttle & Co	Lode	N. & S.	10	8 feet	2,000 feet	Slate	Quartz		40
Idaho	Johnson & Holbrook	Lode	N. & S.	20	2 feet	600 feet	Slate	Quartz		70
Idaho Extension	Grant & Adams	Lode	N. & S.	20	2 feet	600 feet	Slate	Quartz		70
Mountain City	Mountain City Gold and Silver Company	Lode	N. & S.	Vertical	6 feet	....	Slate	Quartz		40

REMARKS.—The Argenta has produced about $100,000 since its discovery, in May, 1869. The deepest workings are on the Argenta, 250 feet; Crescent, 175. California has a tunnel 500 feet long; Excelsior, 400. So far there has been no "petering out." There are probably as many more claims as are here named, that may properly be called *live*, viz: Mammoth, Great Eastern, Nevada, Sunny Hill, Ophir, Kohinoor, etc.

Return of the production of gold and silver in the Cope mining district, Elko County, Nevada, for the year ending July 1, 1870.—*Reported by F. W. Crosby.*

Mill, Cope Mill; owners, Atchison, Drew & Co.; location, Mountain City; mine, Customs; average yield, $60; time of running, commenced running in December, 1869; whole number of stamps in mill, ten; power, steam.

REMARKS.—Entire product of the district, as obtained from Wells, Fargo & Co., and Oppenheimer & Co., in silver and gold, $250,000. The first-class ores were shipped to Reno and San Francisco. Two new mills are being erected: H. Vanse & Co.'s patent pulverizers, said to be 10-ton capacity, and Norton's mill, 13 stamps.

Estimate of costs of mining and reducing ores in Cope district, Elko County, Nevada.—Report by F. W. Crosby, July 1, 1870.

Population of district, 600; wages of first-class miners, $4; wages of second-class miners, $3; wages of surface laborers, $2 50; cost of lumber, $60 to $75 per M; cost of mining timber, 8 cents per foot; cost of common powder, $7 50 per keg; cost of Giant powder, $2 per pound; cost of freight from Elko, 1½ and 2 cents per pound; cost of fuel, $6 to $8 per cord; cost of ten-stamp mill, California pattern, including freight, erection, &c., $20,000 to $25,000.

Bull Run district was discovered and organized in the summer of 1869. It lies about eighteen miles southwest of Mountain City, Cope district, and a good, free road leads from the latter place to the mouth of the cañon at White Rock City, in Bull Run district. The country is well wooded and watered, there being at least 20,000 cords of timber in the immediate vicinity of the mines, and an abundance of water within three-quarters of a mile. The most important ledges so far discovered are the following: The Porter—two to 4 feet wide; shaft, 32 feet down; 100 feet further southwest, shaft 25 feet; still further southwest 380 feet, shaft 12 feet; rich antimonial sulphuret, with some galena, said to assay from $4,000 to $6,000 per ton; 20 tons have been shipped to Reno with satisfactory results. Central—shaft, 12 feet wide; same ore; lode, 4 feet wide; assays $4,000 per ton. Revenue—shaft, 8 feet; lode 4 feet wide; 2 tons on dump; average assay, $150. Montana—lode, 4 feet wide; shaft, 16 feet; assay, $150. Fountain Treasure—shaft, 30 feet; assay, $160 per ton. Blue Bell—6 feet wide; shaft, 18 feet; will mill $100 per ton. Nevada—located for two miles; 4 to 6 feet wide; shaft, 18 feet; mills $100 per ton. This is eminently a self-sustaining mining camp, there having been no necessity for calling in the aid of capital, and the holders preferring to develop their own mines and demonstrate their value, the ledges being of a permanent character and the grade of ore so high that they have paid from the commencement. From the proceeds of the mines the holders have been able from the first to supply themselves with tools, provisions, and all the comforts of life. There are about two hundred people at the mines, and there is every prospect that this number will soon be increased.

In December a correspondent of the San Francisco Scientific Press wrote from the district:

Everything is progressing satisfactorily here in the different mines which are being worked. There are ten tunnels now being run to various lodes, and sixty men at work who will continue to work all winter. The ores sent to Vance's mill, at Mountain City, for reduction, yielded satisfactorily, some giving as much as $1,000 per ton. The Johnson Company are about to start a shaft on their lode. The Sacramento Tunnel Com-

pany are pushing work forward as fast as possible; they are running a tunnel through the main mineral belt of the district, and will cut some eight or ten of the leading mines at a depth of from 50 to 800 feet. Mr. Drew, of Mountain City, is about to remove his ten-stamp mill from that place to here, and will change it to a dry-crusher and add roasting furnaces. He expects to have it running by April next.

The depth of the snow on the mountain is only about three feet. We have had no very cold weather as yet. The amount of ores shipped from this district this summer amounts to 1,723 tons, valued at from $100 to $2,000 per ton. If we had had mills here, over 5,000 tons of ores would have been worked during this last summer, of values ranging from $50 to $2,000 per ton. According to all appearances, there will be over 20,000 tons of ores taken out of the different mines next year; and if there are facilities for crushing, the bullion shipment will speedily demonstrate the value of the mines in Bull Run.

Exhibit of producing mines in Bull Run mining district, Elko County, Nevada, on July 1, 1870, reported by F. W. Crosby.

Name.	Owner.	Character.	Course.	Dip.	Dimensions of claim. Thickness.	Dimensions of claim. Length.	Country rock.	Vein-matter.	Ore.	Average value.	Product for the year ending July 1, 1869.
				°	*Ft.*	*Ft.*					
Blue Jacket	C. Eisenberg & Co	Vein	N. & S	30 W	12	1,400	Slate	Decomposed quartz	Sulphuret silver	$200	About 100 tons of ore have been shipped to Reno and San Francisco, netting from $100 to $250 per ton; milling and freight, $80 to $90 per ton.
Hope	William Porterfield & Co	do	do	10 E	2	1,200	Limestone	Quartz	do	225	
Montana	M. Bunyard & Co	do	do	East	5	1,200	do	do	do	175	
Brigadier	F. Fellows & Co	do	do	do	4½	1,000	do	do	do	150	
Buster	E. D. Bowman & Co	do	do	do	7	1,000	do	do	do	125	
Potosi	A. McKittrick & Co	do	do	do	3	1,000	do	do	do	125	
Found Treasure	J. F. Chellis	do	do	do		2,200	Slate	do	do	225	
Monument	do	do	do	do		2,200	do	do	do	180	
Fifteenth Amendment	George Cowles & Co	do	do	do		1,2 0	do	do	do	150	
Porter	Tucker & Co	do	do	do		1,200	Limestone	do	do	250	

REMARKS.—There are about one hundred veins opened in the district. About one thousand tons of ore are now out. The ores are base, containing galena and antimony. The six first enumerated claims are on the Nevada lodge—probably the mother-vein of the district. The distance from Elko is eighty miles west of north.

The total yield of the ores shipped up to July, 1870, was probably about $25,000.

Bruno district is situated twenty-five miles southeast of Mountain City, and was discovered in November, 1869; the ores containing a great deal of lead and less silver than those of Cope and Bull Run. The district was somewhat neglected until the fall of 1870, when several of the larger ledges attracted much attention. The mines are as yet too little developed to give an idea about their real merit. The following list of mines comprises those in operation in July. No mill was in the district at that time, nor is there one now, so far as I am informed. The ores have so far been beneficiated at Mountain City or shipped to Reno:

List of mining claims in Bruno mining district, Elko County, Nevada, on the 1st day of July, 1870, reported by F. W. Crosby.

Name.	Owner.	Character.	Course.	Dip.	Dimensions of claim.		Country rock.	Vein-matter.	Ore.	Value per ton.
					Thickness.	*Length.*				
Miners' Rest	Martis & Co	Vein	NE. and SW	45° E	3 ft.	1,400 ft.	Limestone.	Quartz	Argentiferous galena.	Assay value, $60 to $300 per ton.
Miners' Delight	Savage & Co.	do	do	Vertical.	8 ft.	1,200 ft.	do	do	do	
Madison	do	do	do	do	4 ft.	1,200 ft.	do	do	do	
Sonoma	do	do	do	do	4 ft.	1,200 ft.	do	do	do	
Mountain King	Klinck & Co.	do	E. and W.	60° E	2 ft.	1,200 ft.	do	do	do	
Big Giant	Doane & Co.	do	NE. and SW	Vertical.	3 ft.	1,200 ft.	do	do	do	

REMARKS.—About 75 tons shipped; average yield, $60. Timber and water abundant; distance to Elko, seventy-five miles.

Spruce Mountain district is situated about forty miles southeast of Humboldt Wells, upon a mountain thickly covered with pine and spruce timber. It is as well watered as any district in the county. The ores are of two classes. Those on the south of the mountain are what is denominated as good milling ore, or chloride; those on the north are what is denominated as the best quality of smelting ore, or argentiferous galena. These mines have now been worked for about a year, during which time many assays have been made from the ores, and both classes have, so far, given satisfactory returns. The mine owned by J. B. Osborne has a shaft down 120 feet, which shows rich ore all the way. On the side of the mountain below is an old incline, which runs into and connects with the shaft. The Latham, Schuyler, and Humphrey are also favorably spoken of. I am not informed as to the actual milling value of the ores, small lots of which are reported to have been shipped from the district.

In *Railroad district*, which was mentioned in my last report, a smelting furnace has been erected during the year, but its operations were unsuccessful. In December, a correspondent wrote about it:

> The smelting works of the Palisade Smelting Company, at Railroad district, are under attachment for debt. If half the reports about the mismanagement of the affairs of the furnace which have come to my ears ever since that "iron tub," called a copper-smelter, was put up last spring, are true, it would have been a blessing to the district if the attachment had been served months ago. These remarks are severe, but just and true. For a long time the representations of parties from that district, and parties who had no intention to falsify, were favorable in regard to the movements of that company, giving them character by announcing the efficient progress of the work; but after months of experimenting at the expense of the labor of the hard-working miners, they have suspended under the influence of a judicial writ. The district is one having merit, but the assumption, presumption, and imposition of small-sized dealers in ore, and experimenters in furnaces, have well-nigh settled it for the present season. Another year, I trust, this district will receive the aid of more practical, intelligent, and financially competent men.

According to the late census, Elko County has 3,447 inhabitants, 439 of which are Chinese.

WHITE PINE COUNTY.

White Pine district.—Mr. Arnold Hague, a brother of Professor J. D. Hague, contributes to the volume on Mining Industry of the Report of the United States Geological Exploration of the Fortieth Parallel, a chapter on the geology of the White Pine district, which is highly interesting and valuable as the first careful and complete account furnished of the subject. The substance of Mr. Hague's conclusions will be here given.

The White Pine Mountains are a southerly continuation of the Humboldt chain, though between White Pine and the Humboldt River there is an interval of depression, where the range sinks to low and insignificant limestone folds or ridges. For a hundred miles south of the river, however, the line of rugged peaks rises 5,000 or 6,000 feet above the plain; and at White Pine there is another culmination in Pogonip Peak, while six miles farther south the mountains are quite low again. The White Pine district, twelve miles square, with Treasure Hill as a central point, lies therefore in a somewhat isolated mountain group. This group is divided into three north and south ridges, measuring in width between the two outer crests about five and a half miles. These ridges are, first, Pogonip Ridge on the west; secondly, the middle ridge, comprising Treasure Hill, the Base Metal Range, and the Blue Ridge; thirdly, Mokomoke, on the east. The highest peak, Pogonip Mountain, is 10,792 feet above

sea-level; Telegraph Peak, on Treasure Hill, is 9,228 feet; Treasure City, 8,980 feet; Hamilton, 8,003 feet; and Mokomoke, 9,239 feet.

Pogonip Ridge trends nearly north and south. The eastern slope presents a grayish-blue limestone, striking with the trend of the ridge, and dipping 22° to 25° eastward. But few and imperfect fossils have been found in it, presenting forms allied to those of Treasure Hill. Mokomoke likewise presents a simple geological structure, the rocks being perfectly conformable, trending north and south with the ridge, and dipping 22° east, except in that part above the saddle connecting with Treasure Hill, where the rocks (sandstone and limestone) are considerably distorted.

Between Pogonip and Mokomoke is the middle ridge, which is at once the most complicated in its geological features and the most important from its mineral wealth. It presents in structure, first, a well-marked anticlinal fold, the axis of which has a general north and south direction; and, secondly, a transverse fracture and displacement, which extends across the ridge at the southern end of Treasure Hill.

The axis of the anticlinal forms the cañon between the Base Metal Range and the Blue Ridge; then, bending around the north end of Telegraph Peak, continues along the east slope of Treasure Hill, 500 feet below the summit, through Pocotillo. This fold is in limestones, the western slope of which constitutes the west side of Treasure Hill and the Base Metal Range, with the exception of the caps of Telegraph Peak and the northern slope of Babylon Hill, which present overlying shale and siliceous limestone. These westerly dipping beds form, with Pogonip Ridge, a synclinal fold.

Treasure Hill is about one mile and a quarter in length, and, across Treasure Peak, one mile and three-quarters wide. On the north it descends steeply 975 feet to the town of Hamilton; on the east, a precipitous wall, 400 feet in height, descends to Pocotillo. Bromide, Chloride, and Pogonip flats are floors of bedded limestone on the west slope, about 200 feet below the crest, the strata dipping 7° to 10° westward. Together, they are a little over a quarter of a mile long by about 550 feet broad, and they terminate on the lower side in a cliff 150 to 200 feet high, below which the strata, much disturbed, strike to the bottom of Silver Cañon.

Pogonip flat, the southernmost of the three, terminates in a low escarpment, at the foot of which occurs the transverse fracture and displacement of strata already referred to. It extends, nearly at right angles with the anticlinal axis, entirely across the ridge, contains the Eberhard deposit, and has given rise to two small cross-cañons. South of this fracture the formation is much broken up by local displacements and sharp folds.

Nowhere in the district do the beds underlying the limestone crop out. The thickness of the formation therefore cannot be determined, but there are at least 1,500 feet of it exposed. The uppermost beds are highly fossiliferous, and belong without doubt to the Devonian period. The limestone is bluish-gray, hard, and compact, highly impregnated with foreign matters, particularly silica, in the neighborhood of the ore deposits, but elsewhere remarkably pure, containing (by analysis of a specimen from the east bluff of Treasure Hill) 99 per cent. of carbonate of lime.

Immediately overlying this Devonian limestone is a formation of thinly laminated, calcareous shale, dark-gray, interstratified with thin, reddish-gray layers, and, so far as known, entirely non-fossiliferous. It has been removed by erosion from the greater part of Treasure Hill,

but is found in the depression between Treasure and Telegraph Peaks, underlies the summit of the latter, may be traced along the western slope, dipping conformably with the limestone, and appears in a thickness of 125 feet on the east side, immediately above Applegarth Cañon.

Over this calcareous shale is a granular, siliceous limestone, containing nodules, and frequently whole strata, which have been completely metamorphosed into chert. The formation is about 100 feet thick, and abounds in crinoids. The top of Telegraph Peak is composed of this cherty limestone. The calcareous shale and siliceous limestone occur also on the summit of the Base Metal Range, and on the east side of the anticlinal fold, along the base of the Blue Ridge, overlying the Devonian limestone. They are ascribed to the same geological period.

The next overlying formation is a black argillaceous shale, about 600 feet thick, carrying seams of bituminous matter, and furnishing most of the springs of water found in the district. Hamilton is in this formation. Above it, as observed on Mokomoke Mountain and elsewhere, occurs a belt of fine-grained, reddish-yellow sandstone, having an estimated thickness of 300 feet, and above this again a body of light-yellow, granular limestone, of which several hundred feet are exposed, but the entire thickness cannot be determined, as the overlying rocks nowhere appear. It is rich in well-marked Carboniferous fossils; and the black shale and sandstone are referred, with it, to the Carboniferous period, though it is not possible from the data already obtained to say positively more than this: that the lower limestones of White Pine are Devonian and the uppermost Carboniferous; while the intervening shale, chert, black shale, and sandstone must belong to one or the other of these periods.

The ore deposits thus far discovered are confined exclusively to the Devonian limestone. The highest stratigraphical position occupied by any mineral deposit yet found is along the line of contact between the limestone and the overlying calcareous shale. The mines at the north end of Treasure Hill, such as the Mammoth, Original Hidden Treasure, etc., occupy this position.

It will be seen that, according to these conclusions, the rocks of Treasure Hill are bent or broken over an anticlinal axis, and, on the east, dip under the rocks of the Mokomoke Range. This explains the absence of silver ore in the latter range. In 1868 I called attention to a probable anticlinal in Applegarth Cañon; but as I made no collection or examination of fossils, and did not carefully study the dip of the strata at the bottom of the cañon, I committed the error of supposing the lower limestones of Treasure Hill to be the same as those of the range eastward, thus locating the axis of the fold too far to the east; and this led to the expression, on page 36 of my report of 1869, "Across the cañon to the eastward the precipitous face of a parallel range shows the continuations of the limestone strata; but the range is of inferior height, and the upper metalliferous layer is consequently wanting, having probably been carried away by denudation. This range dips eastward; and the cañon between it and Treasure Hill probably occupies an anticlinal axis."

Mr. Hague's correction of this erroneous deduction from partial data shows the advantage of careful instrumental surveys and of the collation of paleontological evidence. The matter is not wholly theoretical in value. If certain layers of rock on Treasure Hill are impregnated with silver deposits, it is surely of practical importance to determine whether their continuation may be sought for in the neighborhood, and

whether the outcropping rocks of the vicinity are above or below the desired argentiferous formation.

White Pine was visited by my assistant in September. In his report he says:

Remembering the exceedingly prosperous condition of that locality a year ago, the unparalled excitement produced by the discovery of its rich silver deposits, and the large returns made in a very short time, I must confess that I was astonished to find as rapid a decline as the ascent had been sudden. The town of Hamilton is dull, immeasurably so, and the streets are filled all day with loungers who cannot dispose of their interests, and are therefore forced to stay a while longer. It was, of course, of the utmost interest to me to trace the causes for all this; and I must confess that, on investigation, I cannot find cause for alarm to such an extent as has taken possession of all interested. It is the old story in American mining: first, violent, extravagant and all-absorbing excitement, unwarranted by real facts; and then utter despondency, after the rich ores have been taken out, and the economical working of the larger bodies of low-grade ores must be faced. Such ores still exist in enormous quantities, and there is therefore really no just cause for the prevailing discouragement. But it is true, the extravagance of former expectations must be justly toned down to a point where mining is considered as a business which must be conducted as prudently and economically as any other in order to insure financial success. I have visited Treasure Hill, in company with Mr. J. E. Clayton, who has probably, from his long experience, the most extended knowledge of the geological features and the mines of the district. By his courtesy in pointing out certain features, a speedy comprehension of the rather intricate structure of the region, and especially Treasure Hill, was very much facilitated. There are no ore-bearing *veins* on Treasure Hill, all assertions to the contrary notwithstanding; but it is true that the limestone strata, themselves much tilted and bent, are traversed in numerous directions by larger and smaller veins of calcspar, which are locally termed "spar-dikes," and carry no ore. The main anticlinal of the strata runs almost due north and south on the top of the mountain, and along the east side of Treasure Hill appears to occur a fault. The fissure along this fault is now filled with calcspar, and smaller ones, running obliquely and at right angles into it, contain the same material. As I mentioned above, these spar-veins carry no ore, but on one or both sides of them the limestone is invariably very siliceous, and here occur impregnations and pockets of silver ores. In the richer pockets the ore can, of course, be recognized, but in ores which carry from $30 to $40 silver per ton, there is generally no trace of silver visible. The rock looks like a dark, quartzose limestone, and for the miners the flinty matter is, in fact, the only guide by which to select ore from the country rock. The ore impregnations follow these spar-veins vertically downward, and spread also horizontally between the layers of limestone. In mines of this kind a large amount of barren rock is, of course, invariably transported and crushed at the mills, together with the real ore, simply because the mineral contained in the rock is only very rarely visible. The South Aurora and Hidden Treasure were the only mines of note being worked at the time of my visit. The Eberhardt, once so famous for its rich ore-chamber and stupendous yield, was shut down, as the English company, which bought of the original owners, had not got ready to work their costly purchase. I could not visit the mine, but am reliably informed that, although the old rich deposit is completely worked out, a vast amount of low-grade ores remains to be worked. I hope, for the sake of the company, and also the reputation of the district, that these ores may not prove to be too low-grade to permit profitable working at present. The South Aurora has rich ores and a great quantity of them in sight, and is working a large force of miners.

It has been worked like an open quarry, and the ore is taken from it through tunnels penetrating the barren limestone west of the deposit. The four openings on this mine are very wide, and have reached over one hundred feet in depth. The Hidden Treasure does not look very promising at present, although the company is still energetically at work. I must, however, confess that in this mine less than any other a system of mining could be recognized. There are several companies working on a small scale on the west side of Treasure Hill, on Chloride or Bromide Flats, and the so-called "Chloriders" are scraping up small quantities of rich rock in many places. But, with the exception of the above-mentioned localities, Treasure Hill looks deserted, and thousands of little discovery holes and dumps are the only marks left of the former excitement and bustle. Treasure City itself is almost entirely deserted; a few people remain, who cannot get away, but there is evidently no business going on. Of the neighboring mills and furnaces only a few are running, and those not very regularly.

I have, of course, also visited the Base Metal Range. The ore deposits here occur entirely differently from those on Treasure Hill. They are all lying between and parallel with the limestone strata, and vary exceedingly in length and width. It is characteristic that they invariably occur in certain zones in the limestone, along and near to

thick strata of quartzite, which alternate with limestone and slates. The deposits carry mostly an iron cap, which is from two to three feet deep. Below it occur carbonates of lead mixed with arseniate of iron, and frequently lumps of undecomposed galena are found in the middle of large bodies of cerussite. The number of claims taken up is enormous, but few are actually worked at present. The principal reason is that the percentage of silver contained in these ores is actually too small to pay for working at present. The average contents of silver is only from $12 to $30 per ton in different mines, and the cost of coal being from 25 to 30 cents per bushel, and thirty bushels being used to smelt a ton of ore, while labor in the mines is $4 and in the furnaces $5 per day, you must see that such ores cannot pay for treatment at a locality one hundred and twenty miles from railroad communication. A reduction of wages and freight, in case the long-talked-of railroad from Elko to White Pine should be built, will, of course, remove the obstacles now in the way of profitable working. Of the quantity of smelting ores in the Base Metal Range, there is no doubt they occur everywhere in large deposits, and will eventually be the surest basis for extensive mining industry.

About six miles to the northwest of Hamilton occurs a mineral-bearing zone on White Pine Mountain, which seems to hold out better inducements for working at the present time. Ores from this locality are now in New York for assay, and if they should prove to be as rich as their appearance leads me to expect, this locality will rival the now famous region near Eureka, of which it is an almost exact geological and mineralogical counterpart. Facilities for smelting are here better, and especially the item of coal may be reduced to almost half the Hamilton and Shermantown prices.

The mountain on which the mines are located is here very steep, and about as high as the hill on which Treasure City is located, *i. e.*, a little over 9,000 feet. It is better wooded than most mountain regions in Nevada, but the growth of pine and mahogany is, as must be expected at such an altitude, rather stunted. Charcoal made from such wood cannot therefore be of the best quality; but it is sufficiently dense, when properly burned and guarded against moisture in the winter months, to answer very well for smelting operations. Mining property situated at such a distance from Hamilton, Treasure City, and Shermantown, has, of course, a large advantage over the latter places in the very important matter of the cost of the necessary fuel. Water is here rather scarce, but there is a sufficiency obtained in springs and wells to conduct smelting operations. For the present, and as long as the decomposed ores are encountered in the mines, no dressing is necessary.

The geological formation on White Pine Mountain consists, in this neighborhood, of heavy beds of limestone interstratified with quartzite layers of great thickness. On the west slope, referred to above, the strata are highly tilted, and stand in places nearly vertical. They strike from northeast to southwest, and dip to the northwest. A stratum of quartzite, underlain and overlain by limestone, crosses the mountain here diagonally. In the limestone overlying the quartzite, sometimes close to the latter, sometimes as much as 200 feet above it, occur the mineral deposits. They run with the strata of the country rock.

The San Bernard is located on the west slope, high up, and just over the crest of the mountain. It is hardly sufficiently opened to form a correct opinion of it, but shows in the cross-cut a streak of 12 to 15 inches of solid carbonate of lead and patches in the limestone outside. It runs parallel to another location on the east side of the mountain, which is better opened and has acquired quite a name on account of the abundance of ore which it carries. I refer to the Jennie A., a mine which gives a very fair idea of the nature of these deposits. I am informed that it showed very little outcrop at the top. It is now worked by an open cut about 50 feet in length along the deposit, which shows a large body of carbonate of lead mixed with manganese, arseniate, and hydrated oxide of iron. About 1,200 tons of ore are here on the dump, and the quantity in sight in the mine is very large. The assays go from $9 to $1,000 per ton in silver.

An assay from the San Bernard has yielded $31 per ton in silver. The percentage of lead is about 40 per cent. In neither of the two mines spoken of here have I noticed the mineral stetefeldtite, which, when occurring, is the main source of silver.

The Yosemite claim is 800 feet long, and lies on the west slope about 500 feet below the San Bernard. It is also about 200 yards above the quartzite in the limestone. The deposit is from 2 to 3 feet thick, and is exposed by an open cut 40 feet in length and about 8 feet deep. The ore is carbonate of lead with iron ore and lumps of galena. No assay has been made of this ore, but a piece from the extension higher up the hill is reported to have assayed $30 per ton. The quantity of ore in sight is large, but it is my impression that it will not go high in silver.

The Emigrant is an imperfectly opened deposit, parallel and not far from the foregoing. The decomposed lead ore is about 2 feet wide in the opening.

The Indiana, parallel to the foregoing, and nearer to the quartzite. The ore-streak is 2 to 3 feet wide, and carries more quartz, an indication in this region of greater rich-

ness in silver. The ore is carbonate of lead mixed with arseniate and hydrated oxide of iron, and occasional patches of galena.

Aerolite: Length of location, 800 feet. It lies still nearer to the quartzite down the mountain, and the cut shows a streak of from 3 to 4 inches of stetefeldtite.

Tuna and Iron-clad: Each of these two locations comprises 1,600 feet. They occur below a smaller stratum of quartzite lower down the mountain. The deposits dip steeply, and are evidently larger and more important than any of the foregoing. They show a very large outcrop of iron ore, over 12 feet thick in each case, which have been penetrated downward by shafts 15 and 20 feet deep. Small patches of carbonate of lead occur in the bottoms of the shafts, but the solid lead ore has not been reached.

The Sentinel lies just above the before-mentioned quartzite, in limestone, and shows an iron outcrop 10 feet wide, in which a shaft 15 feet deep shows a streak of carbonate and red oxide of copper and stetefeldtite.

The Alabama is another deposit with a large iron outcrop, in which a shaft 10 feet deep has been sunk. It has just reached patches of carbonate of lead.

The four last locations are by far the most important, and may be expected to carry large deposits of lead and stetefeldtite under the iron cap.

Later in the season large lots of ore from several of the above-named mines were smelted in Shermantown and Hamilton, and those from the Yosemite and Jennie A. have especially given highly gratifying results.

The English company which bought the Eberhardt mine has constructed a new sixty-stamp mill three miles from the mine, and a tramway connects mine and mill, so that the transportation of the ore will cost them only 25 cents per ton.

New smelting works have been erected just above Hamilton by Governor Matteson. In the middle of September, one furnace had already been in blast for a week, and was working admirably. The result of the week's run was about thirty tons of bullion, assaying $180 per ton in silver. For the last two days the work had been gradually increased toward full capacity. The result of the last twenty-four hours' run was 170 bars of bullion, weighing about 8 tons—giving an average assay of $186 per ton. The second and third furnaces were to be blown in before the 1st of October.

About the same time the Ward Beecher was working thirty men, and took out from 30 to 40 tons of ore daily, which netted $40 per ton. Quite a body of ore was struck in this mine, which resembles closely that taken from the Eberhardt in its palmiest days. From the Silver Wave the ore from shaft No. 4 was paying $80 per ton; that from the Hidden Treasure, $74. Schoharie turned out 6 tons daily, worth $40 per ton; the Matilda yielded $80 ore. The Aurora South was working with a large force of men, and had an immense body of ore in sight. Fifty tons of ore were shipped daily, and the last 3,000 tons taken out had yielded $46 per ton.

In November, an English company commenced mining operations on the Aurora North with one hundred men. They extracted low-grade ore for the new mill, and the mine was looking well. In the Eberhardt new rich discoveries of chlorides had again been made, both in the large chamber and on the surface. Most of the mills and furnaces were running, and at Matteson's smelting works refining furnaces were being erected.

Of the base-metal mines, the French, Jennie A., Yosemite, Uncle Sam, and Fay produced large quantities of ore.

The old Monte Christo Mill has been rebuilt during the year; five stamps and a Stetefeldt furnace have been added, and in November the mill was running profitably on ore from the Maryland mine of Pinto district.

In *Pinto district* the Germania, a gold-bearing ledge, has been worked, and five tons of selected ore assayed as high as from $1,500 to $12,000 per ton. Champion ore assayed from $400 to $750; Mountain Chief,

$138. The Maryland is reported 30 feet wide, and samples of the ore found from a two-foot pay-streak in this ledge assayed as high as $1,360 per ton. I am not informed what has been the average of the ore worked, at the Monte Christo Mill.

Robinson district is situated forty-five miles due east from Hamilton, in White Pine County, Nevada. The district came into favorable notice about a year and a half ago, and at the present time has acquired considerable importance, as the development of the claims since the first discovery has established their richness. The country rock is limestone and porphyry, and the former is in places uplifted by diorite. In the limestone and porphyry occur mineral deposits, carrying carbonates of lead, galena, and in some instances red oxide of copper. In the diorite occur *veins* carrying galena with fluorspar as predominating gangue. The Isaac, mentioned hereafter, is one of these. The pure galena from these veins assays $75 in silver. The ores carry always a very large percentage of quartz, and they require, therefore, very close selection to fit them for smelting.

Most of the mines and mining claims, thirty-six in number, are owned by Chicago capitalists, Messrs. Cummings and Waller, and I am indebted to Mr. E. G. Moss, the mining engineer of the company, for much of the following information. The principal mines are the Flying Cloud, Isaac, Elijah, Old England, and General Gregg, which have been worked by the company during the last year. Several hundred tons of smelting ores have been extracted, and the owners have found sufficient encouragement in the appearance of their mines to erect a large furnace for the reduction of their ores.

This furnace is the largest one in Nevada, except the Piltz furnace in Eureka. The furnace is a blast furnace, with four tuyères. Its inside horizontal section is 3 by 4 feet, and the blast is supplied by a No. 8 Sturtevant blower, driven by a twenty horse-power engine. The capacity of the furnace is twelve to fourteen tons per day.

By far the largest portion of the ores cannot be smelted at present, as a preparatory dressing is required to fit them for the furnace. The works being located at the head of Murray Creek, water for this purpose is abundant, and the erection of dressing works is contemplated. Meanwhile the ores are picked by hand, and the first campaign lasted a fortnight and produced eighty-one tons of bullion. The bullion assays $410 in silver per ton.

The ores of at least one of the above-named mines contain some gold. This is the Elijah, but the contents per ton being only from $10 to $12, and the ores being mixed with those from all the other mines, the gold is not at present available. The carbonate ores assay about $110, and the galenas about $90 per ton in silver. This refers, of course, to the ores picked out for smelting. According to Mr. Moss the mines are amply able to supply the furnace, especially after dressing works have been built. Wood in the neighborhood is comparatively plenty. It is the same as found in other portions of Nevada, pine and mahogany, and does not make very good coal except when carefully burned and handled. The Chicago Company employs about seventy-five hands, including furnace-men, wood-choppers, etc.

About four miles from Mineral City, the town of the district, an important mine, the Carbonate, is worked by other parties, and small smelting works are being erected. The ores from this mine assay, according to Mr. Moss, $53 in silver, and about $50 in gold.

Robinson district, like all the mining camps in Eastern Nevada, suffers

as yet from high labor and transportation; but at least in regard to the former there are good prospects of a speedy change for the better.

The following is the number of tons, and their value, worked or sold during the four quarters from July 1, 1869, to June 30, 1870, in White Pine County, as per returns to the county assessor, Mr. W. W. Hobart, to whom, with Mr. J. B. Dayton, his deputy, my thanks are due.

For the three months ending September 30, 1869.

Companies.	Quantity.		Value per ton.	Total value.
	Tons.	*Lbs.*		
Aurora Consolidated	1,328	275	$58 50	$77,792 32
Aurora South	93	315	44 52	4,147 32
Autumn Company	28	1,568	115 40	3,221 78
Atturas Company	56	1,243	114 47	6,495 43
Banner State	46	250	24 65	1,137 24
Butter Cup	9	1,000	83 62	794 44
Black Jacket	10	162	25 14	253 39
Consolidated Chloride Flat Company	3,000	0	46 00	138,007 00
California	10	1,099	126 19	1,331 29
Charter Oak	12	1,786	30 24	389 85
Chloride Company	3	1,947	64 00	254 30
Cutter Company	4	1,195	125 20	575 60
Chihuahua Company, (Centenesy Company)	48	250	76 20	3,670 20
Derby Silver Mining Company	24	727	65 00	1,583 62
Davis Silver Mining Company	2	1,0[illegible]0	254 00	635 00
Domingo	145	0	32 92	4,773 40
Eberhardt	941	0	80 00	75,2[illegible]0 00
Earl Silver Mining Company	83	1,320	208 44	17,440 00
Eclipse Consolidated	27	1,412	74 67	2,000 04
Eureka Silver Mining Company		1,506	2,401 69	1,808 47
Empire and Blair	46	0	45 50	2,095 30
Empire, (Bromide Flat Company)	35	1,858	142 71	5,127 40
Evening Star	7	208	160 13	1,137 55
Emporium	7	1,925	49 10	391 00
Emigrant	27	896	21 36	586 25
Gold Hill	7	1,186	77 67	589 80
Glacier Silver Mining Company	37	1,350	70 69	2,663 13
Greely, S. E		459	5,307 72	1,456 97
Original Hidden Treasure	199	1,373	128 78	25,716 11
Hemlock	4	441	173 41	731 89
Hindoo	2	850	53 63	130 05
Iceberg	784	0	38 40	30,105 62
Industry	138	825	171 26	21,991 86
Industry per Kallmes	35	1,200	110 50	3,933 80
Isabelle	8	838	288 44	2,429 46
Last Chance	4	668	56 38	244 25
Mazeppa	7	0	138 03	966 21
Mammoth	22	1,717	72 23	1,651 42
McRae	4	105	55 50	224 91
McDonald, J. H	8	1,356	117 00	1,012 15
Post Hole	468	740	104 37	48,884 00
Post Hole	829	0	....	8,610 00
Pogonip	2	1,667	51 65	146 35
Peters, F. M	92	0	65 00	5,980 00
Pinto Mining Company	47	1,914	64 99	3,116 78
Summit and Nevada	1,174	0	50 40	59,169 60
Sage Brush	153	1,500	63 70	9,790 00
Seymour No. 10	43	0	68 00	2,924 00
Sierra Pasco	6	352	71 37	440 80
Star and Stewart	3	1,416	82 93	307 50
Truckee No. 7	10	1,714	51 50	559 13
Tom Paine Ledge	53	0	47 17	2,500 00
Trench Silver Mining Company	79	175	102 59	8,113 85
Virginia Silver Mining Company	97	939	101 56	9,899 43
Total	10,328	1,889	....	605,192 86
Average value per ton	....		58 58.9	....

For the three months ending December 31, 1869.

Companies.	Quantity.		Value per ton.	Total value.
	Tons.	*Lbs.*		
Aurora South	2,437	0	$43·59	$106,366 00
Aurora Consolidated	2,672	185	28 48¼	76,112 11
Bromide Tunnel Company	6	835	47 75	306 44
Brown, E. J	1	100	81 83	85 92
Benton Cortes	2	1,500	46 48	127 82
Black Thorn	1	450	52 37	64 15
Brother Conover	15	750	50 00	768 75
Broom Ranger	3	900	95 83	330 60
Consolidated Chloride Flat Mining Company	2,240	0	34 87½	78,120 31
Charles and Therese	26	0	49 88	1,296 80
Chihuahua, (Centenesy Company)	54	0	76 00	4,104 00
Chihuahua Company	37	0	11 10	407 00
Collen Bawn	3	1,428	117 55	436 40
Caroline	4	1,270	100 00	436 50
Combination	39	500	22 40	879 20
Cadiz No. 2	55	0	8 00	440 00
Domingo	180	0	43 20	7,776 00
Eberhardt	781	0	72 00	56,232 00
Eureka Company		1,000	2,223 20	1,161 60
El Dorado	62	1,000	25 52	1,595 00
Eclipse Company, consolidated	39	640	58 29	2,292 00
Fairwell	5	840	31 61	173 85
Glacier Company	10	1,924	32 00	350 79
Gilky	6	992	87 42	567 95
Gorilla	4	775	69 79	306 20
Hemlock	21	1,000	81 25⅓	1,757 00
Hindoo	1	1,672	67 21	123 38
Howard Company	2	988	35 58	88 74
Hartwell	35	814	35 04	1,249 72
Iceberg	876	0	43 01	37,646 76
Josephine	1	120	199 76	211 75
Joe Potts	5	1,700	60 00	351 00
John Cahill & Brother		412	1,728 00	355 96
Jerry Caughlin	1	700	241 24	325 68
Keller	1	1,260	92 31	178 16
Mazeppa	6	562	85 49	537 16
Mammoth	10	1,295	25 12⅓	267 54
Minnesota	1	190	107 10	117 27
Minetta	6	220	33 40	204 06
Milton	1	1,280	37 70	60 82
Mahogany	3	1,250	56 00	203 00
Montgomery	8	900	48 00	405 60
Original Hidden Treasure	956	1,000	51 78⅓	49,998 95
Ohio State	18	1,000	37 00	684 50
Oakland	11	500	54 00	607 50
Post Hole	187	0	29 00	5,423 00
Pogonip and Othello	243	1,000	43 64	10,627 00
Pan Handle	6	0	166 33⅓	998 00
Rice, H. F	34	390	48 00	1,641 36
Summit and Nevada	1,569	0	43 01	67,482 69
Sage Brush	19	700	65 85	1,274 17
Seymour No. 10	51	0	55 00	2,805 00
Sierra Pasco	75	639	43 00	3,238 75
Sangammon	5	385	163 39	848 40
Silver Star	17	0	58 00	680 00
Steele, John		1,450	125 20	90 77
Truckee No. 7	89	1,500	68 50	6,147 87
Tom Paine	20	190	34 39	691 08
Tom Tennant	10	126	34 94	351 57
You Be Darn	3	636	48 00	159 26
Wills, F. H	2	694	64 71	151 87
Zubric	7	390	107 20	771 30
Total	13,002	649		539,657 03
Average value per ton			41 50¼	

For the three months ending March 31, 1870.

Companies.	Quantity.		Value per ton.	Total value.
	Tons.	*Lbs.*		
Aurora South	3,292	800	$29 08	$95,734 70
Aurora Consolidated	1,669	1,570	19 78½	33,032 69
Alta	157	0	10 00	1,570 00
Andrew Jackson, (sold)	2	1,000	25 00	62 50
Butter Cup	4	461	31 67	133 98
Burning Moscow	9	500	82 44	762 58
Binghampton	28	1,750	36 28	1,047 58
Bounty	16	0	12 03	192 50
Badger Hill	7	500	17 00	123 25
Bismuth	13	1,500	15 00	206 25
Consolidated Chloride Flat Mining Company	1,750	0	34 15	59,762 84
Constitution	14	0	73 76	1,032 66
Cliff	10	914	42 73	446 80
Chloride Flat	22	174	44 96	992 97
Chihuahua	24	1,000	24 00	490 00
Cadiz	154	1,000	11 17	1,725 50
Crescent Company	33	1,500	10 00	337 50
Cohalco	13	0	10 00	130 00
Cordoza, E. S	76	0	8 00	608 00
Dell	3	370	50 00	158 90
Don Juan	10	0	8 00	80 00
Eberhardt	888	0	38 30	34,011 36
Earl	307	0	2 00	614 00
Elko	10	1,500	18 00	193 50
Erie	18	1,500	18 00	337 50
Empress Josephine	22	1,000	20 00	450 00
Fletcher Mining Company	15	1,500	117 41	1,849 18
Frazier Company	61	1,000	8 98	552 00
Germania Company	20	0	8 00	160 00
Hoosier State	6	0	8 00	48 00
Hemlock	93	600	21 00	1,959 30
Iceberg	35	580	28 86	1,018 47
Imperial	178	1,000	20 07	3,592 00
Jennie A	15	0	15 00	225 00
Hull, J. C	18	896	46 73	862 11
Lockport	26	1,000	15 00	397 50
Mazeppa	8	1,660	29 00	255 64
Montgomery	9	630	32 45	302 26
Manhattan	16	1,930	35 18	596 87
Mineral Point	22	1,000	12 00	270 00
Molly Stark	128	0	8 00	1,024 00
Miser's Dream	35	0	8 00	280 00
Nelson	1	55	122 90	126 29
Original Hidden Treasure	464	1,000	58 85	27,334 06
Owego	137	830	82 05	11,274 50
Port Wine	4	0	26 00	104 00
Pinto	13	0	10 00	130 00
Rabbet and Steele	22	0	15 00	330 00
Stockholm	7	0	30 00	210 00
Silver Wedge	81	1,000	24 54	2,005 30
Summit and Nevada	148	1,725	41 70	6,214 18
Sage Brush	79	1,250	30 03	2,390 76
Silver Star Consolidated	37	0	106 87	3,953 97
Snow Drop	37	140	37 10	1,375 29
Tom Paine	32	1,240	21 94	715 73
United States	7	500	13 00	94 25
Wabash	178	500	34 31	6,114 83
Total	10,501	1,075	....	310,003 07

Character of ores.	Quantity.		Av'e value per ton.	Total.
	Tons.	*Lbs.*		
Milling	9,092	75	$32 51	$295,569 82
Smelting or base ore sold at dump	1,102	1,000	12 50	13,819 25
Milling ore sold at dump	307	0	2 00	614 00
Total	10,501	1,075	....	310,003 07

For the three months ending June 30, 1870.

Companies.	Quantity. Tons.	Quantity. Lbs.	Value per ton.	Total value.
Aurora South	2,833	100	$47 29	$133,982 67
Aurora Consolidated	568	275	26 79	15,220 27
Autumn No. 2	41	1,307	63 00	2,624 17
Alta	96	0	6 00	576 00
Burning Moscow	26	205	162 23	4,234 70
Butter Cup	5	428	38 70	201 86
Banner State	91	222	31 70	2,872 47
Bourbon	11	0	32 00	352 00
Baldy Green Mandage	11	805	26 39	300 90
Blood & Co.	19	1,900	65 20	1,300 94
Bismuth	89	1,001	15 00	1,342 50
Blue Cloud	12	0	10 00	120 00
Big Treasure	3	1,000	25 00	87 50
Chloride Consolidated	433	0	24 11	10,439 63
Chlorido Flat	86	1,867	50 63	4,401 05
Clyde Silver Mining Company	14	0	38 00	532 00
Chaparral	51	1,000	24 50	1,249 00
Cadiz No. 2	71	0	12 45	883 75
Cadiz No. 1	21	1,000	10 00	215 00
Chihuahua	9	1,000	20 00	190 00
Caroline	13	0	10 00	130 00
Cream City	17	1,000	20 00	350 00
Derby	10	0	160 00	1,600 00
Davis	11	240	37 53	417 24
Delmonico	11	170	68 92	763 95
Double Eagle	17	85	32 00	545 63
Dickinson	11	0	12 00	132 00
Eberhardt	186	1,485	20 40	3,809 53
Empire	2	560	293 00	668 00
Eunice	60	0	22 14	1,326 40
Emersley	12	922	49 70	619 14
Elko	81	1,000	23 00	1,874 50
Empress Josephine	16	1,000	20 00	330 00
Fletcher	7	1,312	202 19	1,579 78
Fay	7	1,500	40 00	310 00
Feeney	13	500	10 00	132 50
Frank Ruland	7	1,000	14 00	105 00
Gennesee	64	743	36 69	2,360 55
Great Valley	74	0	10 00	740 00
Hartwell	15	125	69 57	1,047 98
Hemlock	229	205	26 75	6,128 49
Iceberg	18	1,550	24 91	467 80
Imperial	110	500	18 23	2,010 00
Jennie, A	28	1,000	12 50	350 00
Kingsley	15	500	8 00	122 00
Mazeppa	1	775	514 90	714 45
Mammoth	78	1,000	21 75	1,707 38
Miser's Dream	69	0	10 25	707 25
Montezuma	37	1,000	12 00	450 00
Original Hidden Treasure	2,472	0	48 31	119,425 27
Owego	33	1,352	30 30	1,016 76
Ohio State	6	955	32 94	213 37
Post Hole	158	1,750	19 65	3,119 44
Progress	9	461	55 08	508 39
Promontory	24	0	19 56	463 50
Roman Empire	19	1,000	12 60	243 75
Summit and Nevada	758	1,500	31 12	23,629 72
Sage Brush	24	859	32 42	792 00
Silver Wedge	84	915	20 18	1,704 25
Snow Drop	55	390	97 24	5,367 20
Sierra Pasco	5	565	40 00	211 30
Silver Star	2	1,164	126 35	373 22
Stonewall	19	1,500	47 00	928 25
Seymour No. 2	82	1,000	21 90	1,806 75
Saratoga	4	1,792	47 39	235 52
Saunders	3	566	66 60	218 61
San Pedro	10	955	51 80	542 72
Spanish	4	1,940	37 40	185 80
Stamboul	4	1,441	56 09	264 77
Smith, J. R.		1,550	153 61	119 05
Silver Brick	9	1,000	14 00	133 00
Seto	11	1,000	10 00	115 00
Trench	104	0	44 58	4,532 00
Trench	12	852	36 00	447 53
Virginia	5	1,895	36 40	216 48
Virginia	2	0	64 80	129 60
Wabash	292	685	20 25	5,919 93
Wilson & Graptree	12	0	12 00	300 00
Winnebaha	10	0	15 00	150 00
Wagulealiewam	8	0	20 00	160 00
Total	9,977	1,368	....	386,119 06

Character of ores.	Quantity.	Av'e value per ton.	Total value.
	Tons. Lbs.		
Milling ore	8,973 1,368	$41 09	$368,714 71
Base ore, sold at dump	1,004 0	17 33½	17,404 35
Total	9,977 1,368		386,119 06
Total for year ending June 30, 1870	43,808 0		1,840,972 12

Mr. John Gray, of Hamilton, has kindly furnished me with the following statistics relative to bullion shipments from White Pine district during the year 1870:

Shipments west	$738,417 73
Shipments east	851,852 88
	1,590,270 61

Up to September 1, the bullion shipments are divided in the different months as follows:

Month.	West.		East.	
	Bars.	Value.	Bars.	Value.
January	18	$12,348 45	45	$91,948 47
February	41	40,894 32	41	66,849 13
March	43	49,566 44	22	32,615 36
April	60	83,343 52	28	44,472 38
May	85	108,297 42	38	57,881,09
June	79	80,442 01	37	59,697 14
July	59	68,715 79	50	68,915 45
August	76	75,495 47	55	64,880 78
	461	519,495 47*	328*	487,259 80

West, 461 bars; value	$519,495 47
East, 328 bars; value	487,259 80
Total, 789 bars; value	1,006,755 27

This does not include the base bullion. I cannot give the exact figures in regard to the shipments of this kind of bullion; but, according to the best information at my command, very near a million dollars' worth has been shipped from here.

The census returns for the year ending June 1, 1870, give $2,647,397 as the product from milling ores, and $419,600 as the product from smelting ores in the White Pine County; but I am inclined to believe that many small lots of ore which are given in the mill-returns are reported again in those from the mines.

The number of inhabitants of White Pine County is given in the late census as 7,189, of whom 292 are Chinese.

* These totals are taken, with the rest of the figures, from the return of Wells, Fargo & Co. There is a discrepancy of $392 05 in one, and 12 bars in the other; but I do not know whether the error is in the items or the aggregates.—R. W. R.

LINCOLN COUNTY.

By far the most important developments in this county, and perhaps in the State of Nevada, have been made during the year in Pioche or Ely district.

Ely district lies about one hundred and fifty miles south-southeast of Hamilton, and probably in Lincoln County, Nevada, though doubts have been entertained, and a contest has been going on, in regard to the jurisdiction, between Utah and Nevada.

Very little mention was heard of the district, even among residents of Eastern Nevada, before the fall of 1869. At this time the Meadow Valley Mining Company commenced active operations. The stockholders were principally prominent capitalists of San Francisco. Acting upon the supposition that the ores were of the smelting order, large and expensive smelting works were erected. The attempts at smelting, however, proved abortive and were speedily abandoned; the cupelling of the few tons of lead bullion extracted was also a failure, and the bullion was shipped in a semi-refined state to San Francisco. Similar attempts at smelting, made in furnaces of a very primitive construction, by individual miners, proved equally unsuccessful. The discovery was then made that the ores did not contain enough lead for smelting purposes, and that $50,000 to $60,000 had been sunk without any prospect of a return.

Nothing further was done until the spring of 1870, when the company commenced shipping ore to Hamilton and to San Francisco, with a view to testing its adaptability to the amalgamation process.

In February or March, 1870, 20 tons, shipped to Hamilton, yielded, by ordinary mill process, over $500 per ton. This ore was "free" and gave bullion over 950 fine. A second lot of 35 tons yielded only $190 per ton, although assaying very high; this was of the "base" description. Attempts at amalgamation made in San Francisco on ores of the normal character (base) of this district were also unsuccessful, yielding only from 45 to 55 per cent., according to their richness. The ores of this district vary in character. While the general and normal quality of ore contains enough lead to be called base, and to prove refractory in amalgamation with quicksilver alone, there can be found in certain spots on the various ledges, chimneys of very free ore containing little or no lead, and working readily without chemicals from 75 to 80 per cent. When the "practical millman" of this region receives a lot of this ore for milling, he invariably claims to have discovered a new method of working the ore, and, on the strength of giving a fair percentage and bullion of fine quality, attains a certain amount of fame, which, however, disappears simultaneously with the appearance of lead in his pulp.

From any point of the ledges, pieces of almost pure carbonate of lead and galena can be extracted. Galena is comparatively rare in the Pioche ledge, the property of the Meadow Valley Mining Company, but is found in large quantities in the Burke Mine, its rival, the property of the Raymond and Ely Mining Company. I think that the average percentage of lead, in ores, as they come to mill, will not fall short of 2 to 3 per cent. This is a surmise, not based on actual assay. The "free" ore mentioned above contains 75 to 80 per cent. of the silver as chloride; the baser quality contains only from 40 to 45 per cent. of chloride. A series of "chlorination tests" have shown me that the percentage extracted by amalgamation, with quicksilver alone, corresponds invariably with the amount of chloride of silver in the ore; or, to express myself more clearly, that raw amalgamation extracts only so much of

the silver as is present as horn-silver. Samples of this ore having been brought to Mr. Alexis Janin, in White Pine, and doubts having been expressed as to the possibility of working it without roasting, he commenced a series of experiments of which the treatment with salt and sulphate was the basis. These experiments succeeded beyond expectation. Mr. Janin found that even the base ores yielded as readily to the suasion of chemicals as the Comstock slimes; whereas, when treated with quicksilver alone, the yield hardly exceeded 40 per cent. This does not apply to the free ore, which, as I have said before, amalgamates readily without chemicals; although the yield is materially increased by the use of salt and sulphate. Some time after these experiments had been concluded, Mr. Janin was appointed amalgamator in chief at the Meadow Valley Mining Company's mill, then building in Dry Valley, ten miles from Pioche City.

The mill started up on the 18th of July, 1870, although steam was raised and a few pounds of ore crushed on the 15th, for the purpose of trying engine, etc. The mill at that time had 20 stamps of 650 pounds weight, each making eighty drops per minute; ten pans, H. I. Booth & Co.'s pattern, calculated to hold 2,800 pounds of pulp; five settlers, (conoidal separators, unfit for this kind of ore;) two small agitators; and two concentrators, Hungerford's patent. Since that time the following additions have been made: Ten stamps, 750 pounds; four pans, like the old ones; two flat-bottomed settlers; two 12 by 6 feet agitators, and two revolving buddle-concentrators, patent of Stephens and Randal, 20 feet in diameter. This is an excellent invention, where water is plenty and the difference in specific gravity between "pay" and waste well marked. On starting up the mill there was one serious drawback to contend with. Owing to the miscarriage of a letter there was not bluestone enough on hand to last more than a week. Almost the first ore crushed was that which had originally been selected for smelting, and contained a very large percentage of lead. Nevertheless, it yielded 80 per cent. of the silver. From the moment, however, that the supply of chemicals was exhausted the percentage fell. Pending the arrival of bluestone from San Francisco, there was shipped to mill purposely comparatively poor ore to avoid unnecessary loss. Even after the arrival of bluestone, it was difficult to impress the amalgamators with a sense of the absolute necessity of obeying instructions. In their opinion, it did not make any difference whether chemicals were used or not, and, as far as their experience went in other mills, they were doubtless correct in this idea.

	Quantity worked.		Yield per ton.	Per cent. extracted.	Remarks.
1870.	*Tons.*	*lbs.*			
July 18 to Aug. 31	1,161	400	$66 39	About 58.00	Working 20 stamps, partly without chemicals.
Sept. 1 to Sept. 30	1,027	1,200	114 69	68.55	20 stamps.
Oct. 1 to Oct. 31.	1,071	0	151 86	80.65	20 stamps.
Nov. 1 to Nov. 30.	1,017	900	133 06	82.52	20 stamps.
Dec. 1 to Dec. 31.	1,460	1,987	103 85	81.82	Running partly with 30 stamps.
1871.					
Jan. 1 to Jan. 31.	1,503	1,200	102 48	76.74	Running with 30 stamps.

The falling off in percentage in January is due in Mr. Janin's estimation to the fact that coarser screens were used on the battery. Where

the pans are poor grinders, as is the case with those of this mill, it is, to say the least, foolish to crush \$130 to \$135 rock through a No. 4 punched or a No. 20 brass-wire screen. This is what was done in January. The bullion varies exceedingly in fineness. For over two months, from September 15th to end of November, the average fineness was over 800. Previous to this, and subsequently, the average has been much lower. It is not strange that ores containing so much lead should give very base bullion; moreover, a certain amount of the copper of the bluestone is precipitated and amalgamated, forming a triple alloy of silver, lead, and copper, with a very little gold. The extra amount of silver extracted by the use of sulphate and salt more than counterbalances the amount of copper entering into the amalgam. Thus, paradoxical as it may seem, finer bullion is in reality extracted by the use of sulphate of copper.

Mr. Janin has introduced a very simple method of extracting the greater part of the lead from the amalgam, and consequently from the bullion. The quicksilver and amalgam, after leaving the settlers, is strained in sacks suspended in a large box filled with water, which is heated with steam by means of a half-inch pipe. *Lead amalgam, at the temperature of boiling water, remains liquid*, and consequently strains through with the excess of quicksilver. A certain amount of silver and of copper amalgam also passes through. This is now run off into a smaller box, cooled with water, and when cold is strained in the usual way, leaving an amalgam of lead containing a small amount of the other metals. This lead amalgam when retorted gives bullion containing from 6 to 20 per cent. silver, very little copper, and only a trace of gold. The amalgam remaining in the first sacks gives bullion from 550 to 680 fine in silver, and finer in inverse proportion to the amount of copper in the ore. The lead bullion is shipped from here by slow freight when sufficient accumulates to make a load.

From a charge of ore of normal character the bullion extracted by different modes of working would be nearly as follows:

Amalgamated without chemicals	300 to 350 fine.
Amalgamated with CuO, SO^3 and NaCl, and not strained in hot water	400 to 450 fine.
Amalgamated with CuO, SO^3 and NaCl, strained in hot water.	1st amalgam 550 to 680.
	2d amalgam 60 to 200.

The Meadow Valley ores contain on an average \$5 in gold to every \$100 in silver. This proportion is very constant. Of this gold from 45 to 55 per cent. is extracted. The bullion contains from .0003 to .0015 parts gold. Occasionally a bar will contain as high .003 parts, and at other times so little that it is not taken account of. As I have remarked, the average (\$125) ore contains only from 40 to 50 per cent. of the silver as chloride; in what state the remainder is present I am not prepared to say, but probably as a sulphide, possibly as an oxide, these being the two combinations which yield most readily to the action of salt and sulphate.

The ore is admirably adapted to concentration. The "pay" appears to be mainly in a "heading" of gray carbonate of lead, very easily separated in the sands. The gangue is quartz, the country rock quartzite. All the tailings, after leaving the agitators, flow into a tank from which they are raised by a China pump to a second tank, and from there distributed over two concentrators. The tailings assay on the average about \$25, and the concentrations will range from \$150 to \$300, accord-

ing to the amount of water used in concentration. The apparatus is self-discharging.

One serious drawback in the working of lead ores is the large loss of quicksilver. The loss of quicksilver in working free ores increases with the richness of the ores. I am informed by the former superintendent of a White Pine mill that in milling $100 ore his loss was a trifle less than three pounds per ton. This is excessive for free ores, and it is probably due to the fact that the silver was all present as chloride, and had to be decomposed at the expense of the quicksilver. It is more than probable that sulphate and salt convert the silver into the metallic state. However, it is necessary to remember the fact that, these ores being richer, apart from the question of baseness, it would not be just to compare the loss of quicksilver with that sustained by mills on the Comstock, where ores are much poorer.

During the months of October and November the average fineness of bullion from this mill was over .800. The loss of quicksilver per ton was respectively 2.39 and 2.40 pounds. Both in preceding and succeeding months, with bullion not exceeding .500 to .600 fine, (after passing through the hot-water straining process,) the loss has been as high as 4.76 pounds per ton. This is due probably to the formation of chloride of lead and subsequent formation of subchloride of mercury. Another source of loss is the formation of lead amalgam. This contains but very little quicksilver, having the dull appearance of lead, and floats off in flakes. Lead unites with quicksilver in greater proportion than either silver or copper.

The proportion of retorted bullion to amalgam on the Comstock and in White Pine is as 1 : 5½–6 ; in amalgam containing a large amount of copper as 1 : 7–7½; and in very base lead-amalgam as 1 : 4.

From the foregoing remarks it will be seen that the value of proper proportions of bluestone and salt in working rebellious ores is established beyond a doubt. There are some drawbacks attached to the "process," which are, however, more than overcome by its advantages. These drawbacks are—

1st. Destruction of muller plates and castings, which are strongly attacked by chloride of copper. The same evil is encountered in working roasted ores containing much copper.

2d. The greater loss of quicksilver.

3d. The formation of baser bullion.

This last objection does not hold good, as has been shown, on ores the yield of which is so materially increased by the aid of chloride of copper as is the case with ours.

I am indebted for the important data given above to Mr. Alexis Janin, the accomplished superintendent of the Meadow Valley Mill.

Mills and mining claims.—Prior to the erection of the Meadow Valley Mining Company's mill, Raymond and Ely erected a five-stamp mill at Meadow Valley. These gentlemen were the owners of the Burke, the Creole, and other mines in this district. Subsequently to the erection of this mill a second one of ten stamps was built in Meadow Valley by James Mee, who had a contract with Raymond & Ely for working 15,000 tons at $25 per ton, guaranteeing no percentage. The Raymond & Ely property was recently incorporated in San Francisco. Up to the time of the purchase of this property by San Francisco capitalists, the average percentage extracted from all ores worked at the two mills above mentioned was 42.90 per cent. It is needless to say that they worked without chemicals. They have now struck a body of free ore and are doing well.

There are other incorporated companies, but their claims not having as yet produced much ore are not talked of.

These are the Meadow Valley, Western Extension, and the Pioche Silver Mining Company. The claim of the No. 7 Mining Company was recently purchased by the Meadow Valley Mining Company for $100,000 and merged into this company.

The principal companies operating in this district, and the mills running, up to the end of the calendar year 1870, may be briefly catalogued as follows:

Meadow Valley Mining Company.—Capital stock, $6,000,000, in 60,000 shares, at $100; value of stock at present quotations, $30 to $35, 1,600 feet.

Meadow Valley Western Extension Mining Company.—Capital stock, $600,000, 6,000 shares, at $100, quoted at $6; shaft, 150 feet on three-foot vein; very little prospecting done; 200 feet.

Raymond & Ely Mining Company.—Capital stock $3,000,000, 30,000 shares, at $100, quoted at $20 to $21; —— feet, comprise the Burke and Creole mines and others.

Pioche Silver Mining Company.—Details unknown.

The district, of course, abounds in "outside claims" of various degrees of merit. The above-mentioned are the only prominent ones, with the exception, perhaps, of the Washington mine, not incorporated as yet.

Mills.—Meadow Valley Mining Company's mill, 30 stamps, 55 to 60 tons capacity; Mee's mill, 10 stamps, 18 tons capacity; Raymond and Ely's old mill, 5 stamps, 7 tons capacity.

In process of erection, (will be completed in a few weeks:) Chicago Mill, 10 stamps—a custom mill.

The country around Pioche City is excessively dry and barren. Water has to be hauled into the city a distance of several miles, and is sold at the rate of 6 cents per gallon.

Dry Valley, where the Meadow Valley Mining Company's mill is situated, is ten miles from Pioche City. Water is conveyed to the mill by means of a ditch three miles long. Meadow Valley is an oasis in this desert. Water is here abundant. There is a Mormon settlement, Panaca City, in this valley, where vegetables, &c., are cultivated.

The *Yellow Pine mining district* was visited by Mr. C. A. Luckhardt, mining engineer, during the summer. He has furnished me with the following report:

The northern and eastern part of the State of Nevada, celebrated for its mineral wealth, is densely populated in comparison to its western and southern portion, where an area of nearly one hundred and forty square miles is still uninhabited by white men, and but superficially explored.

On the thirty-sixth parallel, in Lincoln County, about ten miles north of the boundary line of California, lies Yellow Pine mining district, comprising an area of twenty miles east and west by sixty miles north and south. A range of mountains termed Mountain Spring Range slopes gradually southward, leaving Nevada and entering California, and forming one of the boundaries of that great basin which stretches from the Providence Mountains southwestward for one hundred and forty miles to the Pacific Coast Range, and northwestward for one hundred miles and over to the southeasterly slopes of the Inyo or White Mountains. The southern extension of the Mountain Spring Range, called the Potosi Mountains, forms the greater portion of Yellow Pine mining district.

The district is bounded north by the Mountain Spring Range; east by the Opal Mountains; south and west by a dry lake, which is a portion of the basin above spoken of, and called Mesquit Valley. The nearest

mining districts to Yellow Pine are: to the north, the New York district and Pahranagat; to the west, the Amargoza mining district; to the south, the Clark district; and to the east, the El Dorado mining district.

Besides the settlements of these districts, the nearest towns to Yellow Pine are Callville, sixty miles in an easterly direction, and Fort Mojave, a Government post, eighty-five miles in a southeasterly direction, both situated on the Colorado River. At present Yellow Pine is reached from the Pacific coast by the old Salt Lake route, a distance of two hundred and eighty miles from Los Angeles via San Bernardino, over which passes all the travel of this entire southern country from west to east, and *vice versa*. The Colorado River, passing about fifty miles directly east of Yellow Pine, is navigable for five months of the year as far up as Callville, and a wagon-road is under construction, which will change the present western desert route from Yellow Pine to one crossing the Opal Mountains to the Colorado River, and following it to Fort Yuma, a distance of about two hundred miles, where steam navigation commences up the river or down the coast.

The Potosi Mountains have an altitude varying from 5,000 to 6,300 feet. They are a very rugged chain, with deep and abrupt cañons. They have a general north and south course. The prominent points in the vicinity are: Charleston Peak, 8,500 feet, situated in Mountain Spring Range; Potosi Peak, 6,400 feet, situated in Potosi Mountains; Clark Mountain, 6,000 feet, belonging to Clark mining district, and situated in the Opal Mountains.

The greater part of Yellow Pine district consists of hilly and mountainous country, covered with cedar, juniper, and nut-pine, in the lower hills to an average of eight cords per acre, farther up in the mountains to ten cords. The price of cordwood is $2 50 and that of charcoal 16 cents per bushel at Yellow Pine.

On the higher plateau, north of the district and in its northern portion, occur at intervals patches of land fit for agriculture, but of limited dimensions, until the valley is reached, which runs in a southeasterly direction for seventy miles in length, formed by the Vegas and Mountain Spring Range, toward the Colorado River, where larger tracts of fertile soil are met with. Some of these have been settled partly by farmers and the various mining companies of the vicinity, and are yielding fair crops.

In the southern portion of Nevada, for miles and miles, nameless mountains and valleys are met with, and people have settled only where mines have been discovered; but there is no doubt that larger tracts of good soil exist in the highlands north of Yellow Pine, to which country no attention has yet been paid. All the mountainous country northwest of the basin, including Yellow Pine district, abounds in sweet-water springs, carrying from ½ to 9 inches of water, while in the low desert lands west of the district only alkaline waters are found. Yellow Pine is not a new district. Work now visible, done years ago, such as ruins of old furnaces, shafts, and tunnels, and tradition, show that it has been known as a "Potosi" to the old Spanish priests employed at the different missions in California, and also to the Mormons, many years ago. The reasons for abandonment by them are not known, but it is certain that large amounts of lead have been produced for home consumption, regardless of its silver value. The Indians occupying the country in the immediate neighborhood of Yellow Pine are Pah-Utes, a very indolent, lazy tribe. They do not cultivate their soil, and are not dangerous. They relinquish their timber lands gradually to the while settlers by peaceable exchanges for the necessaries of life, and a few energetically administered lessons would soon teach them to regard theft as a crime.

The rocks of Yellow Pine as well as those composing the country north of it have been disturbed principally by volcanic agencies; and in places they have been metamorphosed.

The limestone, which is very often capped by metamorphic conglomerates, has been penetrated by eruptive rocks of various character, which have overflowed both. In places they resemble a very porous lava, and form vertical bluffs often showing large-sized cavities. Belts of laminated bluish limestone, full of minute crystals of iron pyrites, almost resembling a slate, intersect at various angles the general strike and dip of the blackish compact siliceous limestone, which is the predominant, and at the same time the vein-bearing, rock of the district. Subordinate to it, ferruginous dolomite is found. The gangue rock is generally calcspar, with quartz, calcite, anhydrite, and brownspar; with them occur the following ores: galena, with a variable percentage in silver. It occurs coarsely crystallized, poor in silver, and finely crystalline, almost granular, carrying a larger percentage of silver. Accompanying this, pyrites of iron and copper in all stages of decomposition, and zinc and antimony blende are found, but the latter not in sufficient quantities to be a material detriment to the ores.

The veins of the district are of various width, ranging from 2 to 30 feet. Near the surface they are generally irregular; the walls can in many instances not be defined. The disturbances above named, aided by the speedy decomposition of the rocks carrying iron pyrites, are the cause of the frequent recurrence of so-called blind ledges, to which I attribute the fact that up to the present time not more metalliferous veins have been discovered.

Near the surface the generality of the veins represent masses of large ore-boulders and country rock thrown together, and in places cemented by a calcareous earthy mass, which are often the only indications of the existence of a vein in the vicinity. Regularity becomes rapidly apparent, however, as depth is attained; the walls still broken in places begin to show themselves, and the vein partakes of a more uniform character. The ore near the surface exists in detached bodies of various sizes distributed through the entire vein, penetrating sometimes the hanging wall; but as explorations proceed in depth, these bodies run generally into narrower and wider seams lying close to, and running parallel with, the foot-wall, and containing ore more concentrated and richer.

Few mines have been explored as yet, but their general appearance, and the occurrence of such large detached solid ore boulders as are often met with on the hill-sides and in the washes, lead me to expect the discovery of wide veins and large ore-deposits in the future. At present the only noteworthy ones are the Comet, Excelsior, War Eagle, Red Warrior, and Nut Pine veins; and as it is only twelve months since mining has been taken up again in the district, the work done on these is very limited. This is the more to be expected as a great many obstacles have to be overcome by the first settlers in all of these districts surrounded by deserts.

Besides several private individuals owning and working veins, the Silver State Mining Company and the Excelsior Mining Company are operating in the district. I shall describe two mines, one of each company, and of different character, and these will give a good idea of the character of all those discovered so far.

The Comet mine is owned by the Silver State Mining Company, who have located a town-site—Crystal City, named after the springs of the immediate vicinity—on the old Salt Lake route, about three and one-half miles from Mesquit Valley, and in the southern portion

of the district. Here several buildings have been erected. About one mile southeast from and 600 feet above Crystal City, on the southwestern outrunners of the Potosi Mountains, at a total elevation of 6,100 feet above the level of the sea, lies the Comet mine, connected by a wide, well-beaten trail with the town-site. It is at present the prominent vein of the district, is very massive, has compact, blackish limestone as underlie and dolomite as overlie. Its course is north 20° west; the dip, from 20° to 30° east. It shows itself along a vertical bluff of over 100 feet, where the foot-wall is plainly discernible, and can be traced for 2,000 feet and more. The hanging wall is not plainly traceable, owing partially to the disturbances which the mountain has suffered, and partially to the advanced state of decomposition and crumbling to which dolomite is subject when exposed to the influence of the weather.

Work was commenced by a cut at the bluff on the western slope of the mountain, which exposed the vein for 30 feet in width and 40 feet in length, presenting a mass of ore and country rock, the former predominating by far. An incline of 40 feet traverses the vein diagonally below this cut; and here horizontal drifts, 70 feet long, have been run on the vein. The lower workings show the metal to exist in seams and bunches, varying from 4 to 9 feet in width, of solid compact ore, separated by barren bunches of gangue. These bunches and seams of ore at the surface are as likely to yield 5 as 500 tons of ore; there is no regularity observable in their occurrence.

According to the crystalline structure of the galena, the ores are either rich or poor, the coarse being poorer than the fine galena; and the larger the proportion of antimony in the ore, the less the amount of silver. This renders assorting by hand not difficult. A sample of ore, regardless of waste from ore-seams of 6 inches to 11 feet in width, taken along the vein for 336 feet in length, gave 31 per cent. lead and \$36 09 silver per ton, and no gold. The same sample, as it would be extracted in working on a large scale, yielded 50 per cent. lead and \$47 19 silver per ton.

There are three classes of ore which I sampled, observing their proportion to one another as they exist in the vein, in order to get at the actual merit of the whole, viz:

1. The coarse galena, accompanied by antimonite and blende, taken from a bunch 6 feet wide in the incline, which in working the mine will yield probably one-half of the entire ore-bulk of the vein, gave 67 per cent. lead and \$43 79 silver per ton.

2. The finer, closer crystallized galena, as it occurs in the lower works and southward from the cut, carrying lead-ochre, pyromorphite, and minute crystals of polybasite, and which forms about one-third of the bulk of the ore of the entire vein, one sample yielded 50 per cent. lead and \$60 02 silver per ton; another sample yielded 54 per cent. lead and \$64 75 silver per ton; and a sample taken from a pocket containing probably 800 pounds of ore yielded 42 per cent. lead and \$127 19 silver per ton.

3. The fine-grained galena carrying much antimony, of a fibrous texture, as it occurs in small seams, intersecting nearly all the ore-seams in the mine, and which may be called one-sixth of the ore-bulk of the vein, gave 21.3 per cent. lead and \$33 06 silver.

Taking these proportions of the three classes, the average would be an ore of 54⅓ per cent. lead and \$48 11 silver, as it can be taken forthwith from the mine. This, however, may be improved by assorting in mining (causing a probable loss of 15 per cent. of the ore) to 65 per cent. lead and \$60 silver per ton.

The entire excavations made at the mine represent 8,313 cubic feet, and as the work now stands to view two-fifths ore-yield of the above-stipulated quality (from 55 to 64 per cent. lead and $45 to $60 silver value) to three-fifth waste, may be depended upon.

The company have extracted 95 tons of selected ore now piled on the dump, of 63 per cent. lead and $56 54 silver per ton, and about 200 tons of ore, which, when assorted, will yield probably 100 tons of the above average. The company had one ton of selected ore experimented upon by Mr. Taylor at San Francisco, giving 60 per cent. lead and bullion of $225 silver value per ton, which would represent $135 silver value in the ton of ore.

The Excelsior mine is the property of the Excelsior Company of Los Angeles. It is situated thirty-five miles by wagon-road in a northerly direction from Crystal City, in the Charlston Mountains, which are a portion of the Mountain Spring Range. The vein has a general northeasterly course, and dips 35° west. It is bounded on the southeast by heavy belts of grayish sandstone, running parallel with the vein, and has a bluish, compact limestone as overly. The vein-matrix is principally brownspar; calcspar and quartz occur in places subordinately. The ore is argentiferous galena, accompanied by copper ores. Its elevation is 5,600 feet above sea-level. The outcrop has been followed for 70 feet north and south, stands in bold relief from 2 to 4 feet in width, and carries $75 silver value per ton, combined with 30 per cent. lead. The ore is not as rich in lead, and the character of the vein is entirely different from that of the Comet. It does not carry as much antimony, less blende, and copper takes the place of the iron of the Comet. The vein shows, besides smaller seams, a width of 1¾ feet of ore lying near and running parallel with the foot-wall, widening and narrowing in places. An assorted sample of this gave 47 per cent. lead and $94 72 silver value per ton. The mine has been opened by a horizontal cut of 55 feet in length, with the intention to cut the vein at right angles to its walls; but this has not yet been accomplished. A few tons of good ore have been extracted, and the entire work done looks promising for the future.

The two described veins give the general character of the veins of the district; they all conform to these more or less. Little work has been done so far, and the district has as yet not given any yield, as it is but in its infancy.

The facilities for working the mines are good; most of them can be attacked by tunnels. Iron and copper ores, desirable material for flux in smelting, are plenty in the vicinity; and at Crystal City exists a bed of clay containing no iron, little, if any, lime, and is, therefore, an excellent fire-brick material.

In order to give an approximate idea of the actual worth of the district, I subjoin an estimate of the cost of raising and treating 12 tons of ore, worked and extracted under the present circumstances. Twelve tons of ore can be extracted in twenty-four hours by four men. Taking the above estimated average of $48 11 silver value with 54⅓ per cent. of lead, *i. e.*, the ore unassorted, we have—

A. Cost of mining:

Seven hands in all, at $4	$28 00
Rough-assorting on dump, at $1	12 00
Timbering, tools, &c., at 75 cents per ton	9 00
Transportation to smelt-works at Crystal City, at $3 per ton	36 00
Total cost	85 00

equal to $7 09 per ton.

B. Cost of beneficiation:

Extra assorting at the smelting works, (if necessary,) at $1 per ton		$12 00
Crushing the ore in a Blake's crusher, at $2 per ton		24 00
Wear and tear of machinery, furnace repairs, at $3 per ton		36 00
Two galemadores, each 6 tons capacity:		
Labor, four hands, at $5	$20 00	
Three cords fuel, at $4	12 00	
		32 00
Stack furnace, 12 tons capacity:		
Labor, four hands, at $6	24 00	
264 bushels of coal, at 16 cents	42 24	
		66 24
Extra labor at smelting works, four hands, at $4		16 00
Total		186 24

Cost of beneficiation, therefore, $15 52 per ton.

If smelting is carried on properly, at least 80 per cent. of the assay value of the lead and 90 per cent. of the silver value ought to be obtained, representing, therefore, 43.4 per cent. lead and $43 29 silver value. We would have, therefore, from 12 tons—

5 tons 416 pounds of lead, say at 3 cents per pound.	$312 48	Cost of mining, at $7 09.	$85 08
519.48 dollars in silver	519 48	Cost of beneficiation, at $15 52	186 24
Total	831 96	Total	271 32

Therefore, a profit at the mine of $560 64 from 12 tons of ore. At present these 5 tons 416 pounds bullion have to be shipped; we have, therefore, still to deduct:

Freight to Los Angeles, at 3½ cents per pound	$367 00
Freight from Los Angeles to San Francisco, at ½ cent	52 50
Loss in refining bullion, { 10 per cent. in lead, (1041.6 pounds,) at 3 cents	31 24
Loss in refining bullion, { 2 per cent. in silver value	10 38
Assay charges on bullion, tax, etc., 2½ per cent., (of 790.35 dollars	19 75
Total	480 87

To sum up, we have or 12 tons of ore:

Cost of mining	$85 08
Cost of smelting	186 24
Cost of transportation, etc	480 87
Total	752 19

against value of 5 tons 416 pounds bullion, total, $831 96; leaving a profit of $79 77 from mining and smelting 12 tons of ore.

The above description and estimates show that with economy and energy lucrative mining operations can be carried on in the district, not perhaps at first with such magnificent results as many not acquainted

with the facts which now exist in favor of and against the district would at first suppose, but with sufficient profit to justify investment of capital.

It is quite probable that actual practical demonstration in future may prove my estimate in regard to the representation of the quality and quantity of the ores too low, but I have purposely abstained from all flattery, and, on the contrary, underrated the facts. The wealth is there; the district is new; transportation is very high, but this will be reduced in time; and when smelting is once taken up with only half the energy with which amalgamation was taken in hand by the western people, such districts as Yellow Pine will stand among the foremost in rank.

Tem Piute district is about one hundred miles almost due south of Hamilton; by the road now traveled it is one hundred and forty miles. This road passes by the Current Creek and Blue Eagle Ranch.

The general prospect of mines in this district is very fair, and great confidence in them is felt by the owners. The McKenzie claim, worked by Judge Thompson, has about 150 tons of first-class ore on the dump, and work is still progressing in good earnest. The opening from which ore has been taken during the past season is an open cut nearly 40 feet wide, and now in about 50 feet. The ore on the dump is reported to assay from $100 to $300. A tunnel will be started in from this open cut and then work can go on without hinderance by the weather. The Monroe is sinking an incline; the ledge is 12 to 15 feet wide, with a pay-streak of 3 feet. Twenty tons of ore of a quality similar to that of the McKenzie are out. The Amazon is being tested from an open cut. The ore is about the same as in the above-mentioned. It is easily worked, two men taking out a ton and a half in a day. The Rattler shows a high grade of ore, and Judge Thompson intends soon to open it. McMurry is working the Incas and Santa Cruz. All owners of mines are satisfied that at an early day they will be able to make a showing of ore on the dumps sufficient to encourage the erection of a mill to work the supply of ore believed to exist in the mountain. At present, no mill can be reached conveniently. The Crescent Mill is expected to be ready to start up about the 1st of February, 1871. It is a ten-stamp mill situated fifteen miles from the Tem Piute mines, in the direction of Pahranagat. At Ticapoo Springs, eight miles from the mines, there is enough flowing water to drive a twenty-stamp mill, and in the vicinity is plenty of wood—cedar and nut-pine.

Besides the aboved-named, the Savage, Silver Peak, Blue Eagle, Demerara, and several other mines have been opened to a small extent, principally for the purpose of getting enough rich rock out to ship for a test. A vast number of ledges lie entirely idle for want of facilities for reducing the ores.

I have no information as yet in regard to the operations of the Hyko Company, at Pahranagat, during the year, but my impression is that no work of any consequence has been done.

The following are the returns of the mines in Lincoln County during the year ending June 30, 1870. They were kindly furnished me by Mr. N. H. Carlow, the county assessor:

Name of lode.	Mining district.	Number of tons.		Value per ton.	
Quarter ending December 31, 1869.					
		Tons.	*Lbs.*		
Savage	Tem Piute	3	1,800	$86	31
Silver Peak	do	4	1,835	174	04
Blue Eagle	do		757	204	82
Demerara	do	1	954	131	31
Balbec	do	7	1,123	314	18
Virgin Silver	Pahranagat Lake		1,309	87	96
Santa Rita	do		1,720	233	58
Springer	do	1	374	202	31
List	do	3	973	99	25
Crescent	do	50	0	38	40
Richmond	Ely	1	1,435	110	43
Massillon	do	1	308	74	52
Highland	do		787	44	92
Burke	do	13	1,000	123	95
Quarter ending March 31, 1870.					
Service	Tem Piute	2	1,000	152	70
Pioche	Ely	47	0	194	03
Burke	do	400	0	50	00
Quarter ending June 30, 1870.					
Illinois	Pahranagat Lake	46	200	34	77
Sunny South	Ely	8	1,218	74	08
Burke	do	600		55	00
Pioche	do	*75		500	00

* Shipped to San Francisco by Meadow Valley Mining Company; estimated.

The census reports 2,985 inhabitants, 23 of whom are Chinese, in Lincoln County. In this is included the Mormon farming population of the Rio Virgin, Los Vegas, Overton, St. Joseph, St Thomas, West Point, and smaller places, which numbers 762 souls, leaving a population of 2,223 for the mining districts.

ESMERALDA COUNTY.

Attempts have been made during the year to revive operations in this county, a number of San Francisco capitalists having interested themselves in the district. No reports of their success have been received. The Red Mountain gold mines have produced a considerable amount of bullion, but their condition is substantially as described in my last report. The company's mill will be, it is said, still further enlarged, and some further improvements for cheapening the transportation of ores are required, as the cost of keeping mules in that desolate region is very burdensome. The mill, which now contains forty stamps, produced about $100,000 during the year ending June 1, 1870. The total product of the county for the same period was reported to the Census Bureau as $595,000, in which the following sums from different mills are included: Keene, $50,000; Tombs, $60,000; Pioneer, $40,000; Willson, $100,000; Wide West, $20,000; Young, $40,000; Johnson, $35,000; Wheeler, $50,000; Greenback, $50,000; and Bourse, $50,000. The principal mines worked besides those already mentioned were the Gold Mountain, Morgan, Del Monte, Snow Squall, Pocahontas, McCormick, Black Sulphuret, and Black Jack, of which the latter produced $30,000 worth of ore, and the rest from $5,000 to $10,000 each.

CHAPTER III.

OREGON.

The reports from the mining districts of Southwestern Oregon are extremely meager. In Jackson County there were many placer-claims operated during the year, but they paid but poorly, the average yield from some fifty of the principal claims being but $3 per day per hand. Wages are $50 per month, and other expenses absorb the remaining margin. The industry is falling mainly into the hands of Chinamen, who conceal as far as possible both their expenses and their profits.

In Coos County there has been some successful placer-mining. The Pioneer Company, Colonel John Lane, superintendent, produced some $12,000 during the year ending July 1, 1870. Placer-mining along the beaches of Northern California and Oregon has also been continued, and the yield is reported at $10 per day per hand for a small number of men and for a precarious season. Stoppages and other expenses reduce profits to a low figure. It is found, moreover, that these beach deposits, though apparently renewed after storms, high tides, &c., are not inexhaustible, but may be gradually worked out like any others. This naturally follows from their origin, which is undoubtedly the quartz veins of the Coast Range.

Of quartz-mining in this part of the State I have nothing to report this year. A few enterprises, alluded to in a former report, have been feebly pushed, but the extent of operations has not been such as to warrant me in causing a special examination to be made. I am under obligations to Mr. Samuel C. Mills, agent of Wells, Fargo & Co. at Portland, for the following figures of express shipments of bullion for 1870:

January	$108,300	November	$169,200
February	98,000	December	212,800
March	18,400		
April	88,800	Total	1,547,800
May	43,500	Private hands, (estimated)	250,000
June	165,700		
July	170,400		
August	168,700	Total from Portland	1,797,800
September	151,900		
October	152,100		

The treasure shipments of Wells, Fargo & Co. in previous years have been as follows:

1864	$6,200,000	1867	$4,000,000
1865	5,800,000	1868	3,037,000
1866	5,400,000	1869	2,559,000

The reduction in the product of gold is not so great as here appears, since the diversion of the bullion from Eastern Oregon to other routes, and the transmission of considerable quantities in private hands or through bankers, (in 1868 $640,850, and in 1869 $419,657, by a single house in Portland,) account for much of the diminution.

I estimate the production of Oregon and Washington (very little

gold, however, having come during 1870 from the latter Territory) at $3,000,000, the same as last year, according to the latest statement in my report, on page 205, which corrects the estimate of $4,000,000 in my introductory letter. The reason of this and other similar discrepancies is explained elsewhere.

As I have indicated, the principal mining industry of the precious metals in Oregon is now to be found in the eastern part of the State, on both sides of the Blue Range.

Meager returns from Cañon City and neighboring districts indicate a somewhat increased production, though mainly by reason of the influx of Chinese, who succeed, by purchase in most cases, to the claims formerly worked by the whites, and who, by their superior patience and economy, continue the production of gold in many localities where it would otherwise cease. It is very difficult, however, to ascertain the amount of production from such sources. Thus the reports from sixty-four placer-claims in Grant County, eleven of which are worked by white men with paid labor, and the remainder by Chinese owners, show for the former a yield of $4 per day per hand, and for the latter only $1 30. There is no doubt that the Chinese have in this case concealed the actual amount of their production, reporting an aggregate of about $126,000, when the true amount must have been at least twice as great. Some of the claims worked by whites yield during the season $10,000 or $12,000. I have not heard of any cases during last year in which single claims have exceeded the latter figure.

Hydraulic mining has been carried on to some extent in Upper Cañon, Maryville, Olive Creek, and Quartz Gulch districts, and especially at Granite Creek, where six claims were reported in June, 1870. The average season is between four and five months; the average wages, $4 per day for white labor; and the average yield, $8 per day per hand. Among the larger operations are those of Thompson & Co., near Maryville, producing about $10,000 in nine months with four men; Dick Eagan & Co., Granite Creek, ten men, three months, $16,000; W. H. Clark, Upper Cañon, three men, two months, $8,000.

Quartz-mining has made but little progress since my last report. The Prairie Diggings mine, therein described, has been worked somewhat, and reports a product of about $10,000 for the year ending June, 1870. The quartz is of low grade, but very abundant and cheaply mined and milled. Quartz-mining operations by the John Day Company and others in Elk district are spoken of as highly promising, but have not yet attained to a regular production.

This part of Oregon suffers from imperfect and costly communication with commercial centers. There is a good road from Cañon City to the Dalles, and another (now, I believe, disused) to Boise; but the transportation of the mails exclusively by way of Umatilla has left the settlements on the John Day and its tributaries stranded, as it were. The discontinuance, since the Indian war, of the military posts in this region has deprived the farmers of the fertile bottom-lands of their best market, and checked to some extent the further development of agriculture. A greater activity and progress may be observed on the east of the Blue Range, in Baker and Union Counties.

I am indebted to Mr. E. W. Reynolds, agent of Wells, Fargo & Co. at Baker City, for much of the following information concerning the operations of 1870 in that part of Oregon:

The shipments of Wells, Fargo & Co. from Baker City for nine months of 1870 averaged $50,000 per month of gold dust and bullion, and the amount carried out of the country in private hands may safely be put at

$10,000 a month for that period. For the three months of comparative inactivity $20,000 per month will cover both express and private shipments. The total shipments of gold from Eastern Oregon, exclusive of Cañon City and other districts west of the Blue Range, amount therefore for 1870 to $600,000. The following items refer to the different districts here included, with regard to which my last report may be consulted for particulars of location, etc.:

Pocahontas district.—The placer-mines of this district have done very well, considering the dry season, and a number of rich discoveries have been made in the way of quartz lodes. Among these the Gunboat lode is perhaps the most prominent. It was discovered beneath a gulch deposit after the auriferous dirt had been washed off. The surface-rock is reported to be worth $100 per ton; a lot crushed at the Ruckel mill, Baker City, containing, it is said, much wall-rock, yielded $30 per ton. Messrs. Simonton and Olds are about to remove the Humboldt Mill from Eagle Creek to the vicinity of the Gunboat lode. This is a steam-mill of twenty stamps, and will run on custom rock. In the same district the Young America, (4 feet wide, decomposed quartz,) Stonewall Jackson, Kelley, and other lodes promise to yield fair milling ore.

Auburn.—Placer-mining in this once famous district has not been very lively during the year, judging from the business of the Auburn Canal Company, which sold but little water. The large amount of gulch-mining heretofore done in this neighborhood, however, has left the cañons in excellent condition for the discovery of quartz lodes, and accordingly I am not surprised to learn that several promising veins have been found. One of these, the Oro Fino, about half a mile from Auburn, promises exceedingly well. It is owned by E. M. White & Co., and has already been opened to the depth of 104 feet, showing a vein of 18 inches, carrying free gold in white and decomposed quartz.

Fort Sumter, Granite, and Olive Creek districts, in Grant County, all did well in placer-mining during 1870.

Humboldt Basin has suffered some from the dry season, but has produced pretty well, having been blessed by a considerable influx of Chinese from other districts.

Amelia City appears to have fallen off somewhat, but will doubtless revive when the completion of the El Dorado ditch furnishes an abundant supply of water.

El Dorado or Shasta district* promises to become this year one of the most important in Eastern Oregon. The ditch commenced by Carter and Packwood has been sold to a Chicago company, which has enlarged it to 8½ feet on the top, 6 feet at the bottom, and 3 feet in depth, thus giving it a capacity of over 3,000 inches. Fifty-two miles of it have been already completed, and it is expected that thirty-nine miles more will be constructed this spring, bringing into camp the waters of the Malheur and Burnt Rivers, and furnishing an unfailing supply to a large area of rich placer-ground. The mines of Malheur City and Amelia City will be supplied from this ditch. The name of the company is the Malheur and Burnt River Consolidated Ditch and Mining Company; the president is Mr. B. D. Buford, Rock Island, Illinois; and the superintendent, Mr. J. H. Johnson, El Dorado, Oregon. The company runs two stores, receiving goods direct from Chicago.

Eagle Creek, Cooster, or Koester district has an excellent prospect for the future. There are no new developments reported in quartz-mining;

* See my report of last year, pp. 228, 229. On the former page Shasta is miscalled Sparta, by a typographical error.

but the great hinderance to the placer-mines, the scarcity and dearness of water, is in a fair way of removal. Messrs. Packwood and Stewart, of the old Burnt River Ditch Company of Eldorado, have surveyed a ditch to bring the Eagle Creek water twenty-one miles into Koester diggings. It will be completed next September, at a cost of about $50,000; and it is believed that it will afford facilities for a largely increased production of gold from the placers of this part of Union County, which are known to be extensive and valuable. Blue Gulch, Horn Gulch, Maiden Gulch, Red Gulch, and other localities have given high returns to prospectors, the report being "50 cents to three pans of dirt." The gold is of fine quality.

The old Ruckel or Union mine (see my report of last year, p. 230) is now worked by Messrs. Brown and Virtue. They have sunk a shaft from the lowest tunnel level, over 50 feet, and intend to go to a depth of 200, drifting east and west at 100 feet. The presence of water has necessitated the introduction of a pump, which is worked by a one-horse whim. The ledge is 20 inches wide at the bottom and is dipping north. The quartz is somewhat easier to extract than it was in the upper levels. The shaft is 6 feet by 9. These workings are on the Rocky Fellow, which was the vein principally worked by Colonel Ruckel, though the Union, which is probably a branch, has yielded well. It will be seen that operations at this mine are confined mainly to preparation of new stoping-ground, as might be expected from the condition of the work as described in my last report. The foregoing particulars are received from Mr. A. H. Brown, one of the present proprietors:

Rye Valley district has done as well as the dry season would permit in placer-mining. Some little prospecting for quartz has been done, and partial success rewarded the labors of the seekers—W. Green having discovered a small vein of gold-bearing quartz in the vicinity of "Humphrey's Gulch," which prospects well. This gulch has remunerated the placer-miners engaged there for a number of years, and perhaps this discovery may lead to a more extensive exploration of that locality, possibly unearthing the source from whence these placer-claims have been fed.

Little attention for the past year has been paid to the numerous ribbon silver-bearing veins discovered in the district. The presumed reason lies in other and more pressing pursuits of the locators. What little work has been done has rewarded the prospectors by disclosing ore which, by assay, yields, in some cases, as high as $572 per ton. The Monumental, Green Discovery, Mountain, Washington, and Rising Sun gave flattering indications. With the exception of the two first-named veins, however, the large number of the locations in each company has been a serious drawback to development. But the time is drawing near when, by law, the greater portion of these locations are declared vacant through non-performance of work; and it is hoped the claims will pass into more energetic hands.

About 30,000 feet of lumber for the Rye Valley Bed Rock flume was on the ground last December, and it was expected that work would be commenced on that undertaking when the season permitted.

The following account of the early settlement, character, and present development of the mines of Union and Baker Counties was prepared by Mr. W. H. Packwood, of Baker City:

In the fall of 1861 Mr. Griffin and party of men, in prospecting in the Blue Mountain Range, discovered what is known as Griffin Gulch, a tributary of South Powder River. The gold found was coarse, and in sufficient quantities to warrant them in locating for mining purposes. At that time the only settlement east of Blue Mountains—I might

say in Oregon south to the California line, and eastward to Snake River—was that of Mr. B. Brown and a few others, in Grand Ronde Valley, for grazing purposes. George Abbott and two or three other men had started beef-cattle from Umatilla Valley for Salmon River mines, but were driven back from Snake River to Grand Ronde Valley by the Indians and snow. Here they wintered their cattle without any loss, and be it remembered this was the most destructive winter for cattle since the first settlement of Oregon. To get supplies to Griffin Gulch the miners had to go to Walla-Walla, or the Dalles, a distance of one hundred and fifty to two hundred and fifty miles.

As soon as the fact that paying gold mines had been discovered on the waters of Powder River had become known, Mr. Abbott drove the cattle designed for Salmon River to Blue Cañon, where Auburn now stands, which had been found by Mr. Kirkpatrick, George Hall, and others. Blue Cañon was distant from the Discovery or Griffin Gulch about four miles. The character of the gold found was excellent, from fine grains to nuggets weighing from one to three and more ounces. Mr. Abbott believed that a new and valuable gold-field was discovered here, and going to the Dalles, together with Mr. Knight, bought and shipped some goods by pack-train for Blue Cañon. Mr. Du Gay also arrived with goods about the same time; Messrs. Cranston, Moore, Norcross, and others soon followed with goods. Before and after all these, miners from every point of the compass came pouring in, ready for anything new in the way of mining. The town of Auburn was laid out in lots about June 16, 1862. Mr. J. W. Peters and Knight, Abbott & Packwood, had buildings up for stores, and moved from their tents into them before the 4th of July following. The population in that vicinity dependent for supplies from Auburn was not less than from three to four thousand persons by September of the same year. At one time, in 1862 and 1863, Auburn had forty stores and saloons. There was a large number of emigrants from the States that year for Salmon River and Oregon. A large proportion of these remained in the vicinity of Auburn and Powder River Valley.

Auburn is justly entitled to be called the mother of mining camps in Eastern Oregon and Western Idaho. From Auburn prospecting parties were fitted out and the country explored in every direction. Grimes's party discovered Grimes's Creek; in fact, the great Boise Basin. Ross Smith, Jack Long, and others found Granite Creek, and laid out the town of Independence on this creek about July 4, 1862. Cañon City was largely settled by Auburnites. The Owyhee mines were the result of discoveries made by Uncle Tom Turner's party in search of Sinker Creek, and by a party from Idaho which discovered Reynolds and Jordan Creek. During this time but little work, permanent in its character, was done, miners being generally on the hunt for strikes, or a big thing. They did not begin to look for claims yielding under eight to sixteen dollars per day per hand until about 1864. On the contrary, each miner seemed to be determined to expend his last dollar before locating. At the same time every miner brought with him his peculiar ideas of a mining country, formed in the mines they happened to come from. We had miners from California, Australia, Cariboo, Florence, Pike's Peak, and Mexico; but the surface indications here do not precisely resemble any of the above-named mining localities. Because it was not dry and barren, as in most mining districts, the country remained almost wholly unprospected. There was another class, however, that kept at work, regardless of the surface indications in the country, and to this class is owing almost entirely the permanent settlement of these two counties as mining districts. Almost wholly without other capital than that obtained from the ground worked, they have, in eight years, demonstrated the fact that Baker and Union Counties are both rich, and almost unlimited, except by their own boundaries, as to the extent of their placer-mines.

The character of the mining country is this: It is covered with a fine, loamy soil, and with excellent bunch and rye grass. In many places decomposed quartz and float slate, granite and volcanic rocks, appear. The general appearance would lead to the belief that the country has been under water for a long period of time, and that large streams of water have crossed the country in a different direction from that in which they now run. In many places heavy deposits or channels of washed gravel have been found. The country is broken up in gulches, flats, and hills, fronting on and leading into and surrounding the main large valleys that lie on the present main streams of water. In other words, the mines are confined to the table-lands and foothills of the mountains. The depth of the mining lands runs from almost bare bed-rock to sixty and more feet deep, and, to work it with profit, water is required for ground-sluicing and hydraulic mining. In many places the ground is sufficiently rich to pay working in rockers. The entire country, up to this time, has been almost wholly dependent on snow-water for mining purposes, and the country is filled, in almost every district, with what are here usually called dry ditches. The fall of snow is irregular: some years the dry ditches have water twenty days, other years from forty to sixty days. There are some permanent streams that furnish water sufficient for large ditches; but as these streams cut well back, and lie deep down in the mountains, long lines of ditches are required to convey them to the mines, and to build long ditches capital

must be obtained. The living streams available for ditches are Burnt, Malheur, and Powder Rivers, and Eagle Creek. Among the first ditches built here were those of Conoyer on Powder River, Davidson & Carter's, and Kirkpatrick & Co.'s; for Auburn mines the water being taken from Elk Creek. The Griffin, Stafford, and Littlefield ditch from Elk Creek to Griffin Gulch.

W. H. Packwood, Abbott, Fuller, Ward, and others organized the Auburn Water Company in 1862, about September 15th to 20th; sold in November to some Portland capitalists—Messrs. Ladd, Brooke, Thompson, Ainsworth, and others, who carried the enterprise through the next year. This enterprise was one of the greatest inducements to the permanent settlement of Powder River Valley, and the capital invested by the last-named gentleman is almost the only outside capital ever invested in these two counties.

Packwood, Perkins, Statsman, and Kitchen built the Clark's Creek ditch in spring of 1863, which ditch has been and is now a good piece of paying property. The Rye Valley ditch was built in 1864, and from time to time almost all the springs in the mountains and streams that run water while the snow lasts have been improved for mining purposes. The main or living streams so far are idle. In 1863, W. H. Packwood, Ira Ward, Robert Kitchen, and J. N. Hull organized the Burnt River Ditch and Mining Company. This was an undertaking and enterprise of first magnitude, and founded more on the belief as to the general existence of paying gold mines on the Burnt River and Willow Creek mountain sides than from any positive knowledge of their existence. In the fall of 1864, W. H. Packwood hired a party of men and sent them to prospect the Willow Creek side of the mountain. They found from a color to three bits to the pan, gold coarse order. They could find it in almost every place, in the flats, hills, and gulches, in paying quantities. In the fall of 1863, A. C. Goodrich ran trial-lines for a ditch. In 1864, Charles Barrett, civil engineer, surveyed and staked the line for a ditch from Burnt River to Shasta Pass or Gap.

Now, to understand the character of the enterprise, it is necessary to know that Burnt River and Willow Creek are two streams rising in a spur of the Blue Mountain, and running parallel with each other a distance of from forty to fifty miles, separated by a dividing mountain that rises in altitude from one to three thousand feet. The slopes of the divide separate Burnt River and Willow Creek from each other, on an average, about fifteen miles. Now, the object of the company in selecting Shasta Pass—a low gap in the main divide—was to run a line of ditch in such manner as to command both sides of the mountain. By Mr. Barrett's survey, the distance from Burnt River to Shasta Pass was found to be over eighty-eight miles for line of ditch. By commanding Shasta Pass as a terminal point, it was believed by the company that their line would command a larger extent of placer-mines than was ever before commanded by any ditch in the history of mining in California or elsewhere. From Shasta Pass, the ditch-line could be extended on the Willow Creek slope a distance of about thirty miles to Snake River. On the Burnt River slope, it could be prolonged sixty and more miles, Snake River being the only limit to its extension. After Mr. Barrett's survey in 1864, the Indians were hostile for over two years, so as to render life and property unsafe, and no further work was done until 1867. At this time Mr. T. J. Carter, of Portland, became interested in the company, and work was resumed in June, 1867—Mr. T. J. Carter, president, and W. H. Packwood, secretary; capital stock, $144,000. In 1867, 1868, and 1869, the company completed nearly fifty-eight miles of the main line, commencing at Shasta Pass and running to water. They expended over $100,000 on the work of construction in that time. Their line of ditch in these fifty-eight miles took in the small streams fed by snow, and had tapped East Camp Creek. In the spring of 1870, the company puddled their ditch with the snow-water and Camp Creek, and had water for sale for a few weeks on the Willow Creek side of the mountain. The water sold by them realized an average of about 60 cents per inch for ten hours' use.

In the spring of 1869, Mr. Uriah Perry, an old ditch-man in California, came into this country, and having examined the mines, and knowing practically that Burnt River and Malheur were the only available living streams of water in this country, and that the placers were extensive, he projected forming a company in Iowa and Illinois for the purpose of securing the water rights and mining extensively. He enlisted Mr. J. H. Johnson, who went back to Chicago and there succeeded in inducing Mr. Buford, of Rock Island, to come out and examine the country. The result was, after some weeks' examination, that Mr. Buford purchased nearly the entire stock and control of the Burnt River Ditch Company's property, including large tracts of mining land, on liberal terms, fair profit to seller and purchaser. Mr. Buford, being a man of great wealth, proposed to double the size or capacity of the ditch constructed by Carter and Packwood. Their ditch was designed to convey and store up sufficient water to furnish about 2,000 inches for ten hours. Mr. Buford's directions would require the ditch to be enlarged to about 8 feet top, 6 feet bottom, able to carry water 3 feet deep. Mr. Johnson, secretary and superintendent for the company, pressed the work in good and bad weather, from October, 1870, to January, 1871, and has the ditch about completed to the size above named, or very near it. A light wagon or buggy can be driven

in the ditch, and two horsemen can ride through it abreast comfortably. This company is known as the Malheur and Burnt River Consolidated Ditch and Mining Company; Mr. Buford, president; J. H. Johnson, secretary; capital stock, $1,000,000. Mr. Buford having secured the Malheur River water, this company now own and control all the available living water for mining purposes in these districts, to wit: Eldorado, Malheur, Amelia City, Rye Valley district, Clark's Creek, and Burnt River Slope—say, at a low estimate, mining districts that together would form one district sixty miles long by ten to twenty wide.

All the water in this district is from the snow, or natural water, and usually it only affords a supply for a small number of claims for a few weeks. This is the largest ditch in the State of Oregon, and will be one of the longest on the Pacific coast when completed, as in time it will be extended sixty miles from Shasta Pass. About thirty miles more will finish the main line or trunk, and the company intend doing that work early this spring. One objection to long ditches is loss from evaporation. This line of ditch lies on the north and west side of the mountain, and has for feeders on the line not less than eighteen streams of water that run from 5 to 100 inches each, and should more than make good all loss by evaporation. The country through which the line runs is a favorable one for ditching, being a clay loam and slate country. The ditch, when completed for running water, may cost from two hundred and fifty to three hundred thousand dollars. Very many will say: Will the country and mines justify the investment? We have no hesitation in saying it will pay for an investment of $1,000,000 for water to supply the named mining districts by the owners using even ordinary care in the management of the same. Let us see. The old company sold water, first head, 30 cents; second head, 20 cents; third head; 10 cents per inch; fourth head, 5 cents. Average about 60 cents per inch for ten hours. Many persons may not understand what we call in mining, first, second head, etc. It is the same water first sold being sold over several times, each time for a lower price than before, as the water depreciates in value from use. In Mormon Basin, and through Mr. Kelly's Ditch at Amelia, the water of the upper camp is used in the lower from twelve to fifteen times. The Malheur and Burnt River Ditch Company, when their works are completed, can sell say 4,000 inches for ten hours. Say that they only realize for all uses 25 cents per inch, (they should at a lower estimate realize 40 cents to 50 cents, as the water will be used over three times in many places,) their sales would amount to $1,000 per day. They can run and sell water from two hundred and thirty to two hundred and seventy days each year. Their current expenses should not exceed from fifteen to twenty-five thousand dollars per year, and become less with age on the ditch. Again, the question, How long would this last? The fact is, the available supply of water for the districts named cannot equal the demand, and the water that can be obtained will not suffice to work out the mines on this line in the next one hundred years.

A few years ago a few men believed this true; to-day thousands do. Again, independent of selling water, there are other inducements for investments in ditches which did not exist a few years ago. In this case the one company owning an absolute monopoly of the water can, if they desire, purchase at nominal prices from the United States and others large tracts of mining land, and by them conveying water so as to be available to mine their land can raise its value immensely; or, as in California, they can construct large flumes and hydraulics, mine extensively with large streams of water, so as to make the water save the labor of men.

Chinamen are in the country and can be hired cheaply, or ground could be rented to them with water to work it. The monopoly a ditch company has here gives them as absolute a right to tax the mines in some form or other as the Government has to tax the people. Another thing is this, poor and rich land can be worked now at the same time; in earlier days only the rich land could be worked in consequence of high prices. Now, however, a man can live quite cheaply, labor can be had for $2 50 to $4 per day, where in past years it was from $5 to $8; hence, when water can be obtained, every class of mines can be worked; for it is a truth that miners will mine ground for less than wages, and take the chance of more than wages. The gold dust in Eldorado, Malheur, Amelia, Clark's Creek, and Burnt River Slope is worth from $16 to $18 per ounce.

The largest piece ever found in Baker County was at Gimletville, a small camp on Burnt River. It was worth nearly $4,000. Chinamen have both bought claims at nominal prices and have paid as high as $35,000 for them. The completion of the Malheur and Burnt River ditch will give steady and permanent employment to a large number of miners, and add to and stimulate the agricultural and grazing interests of Baker and Union Counties.

Following down Burnt River from the mouth of Clark's Creek to Snake River, a distance of fifty miles, the river cuts through the mountain range that runs northward and parallel with Snake River. So far as the river has been tried, on the bars and hills, on and near the river, gold has been found in paying quantities. In fact, from one to fifty dollars per day have been made with the rocker. From Clark's Creek to Express Ranch, for twelve miles the river forms a cañon. In places hundreds of feet

above the river, bars and hills are found that would pay largely with water for hydraulics and flumes. Some of these hills and bars have been drifted and worked in rockers, and good returns made in that manner; but as the gold is not confined to the bed-rock, but found in all the dirt, in some locations 20 to 60 feet deep, no very profitable work can be done without an abundance of water and flumes. There is also every reason to believe that the bed of the river is rich for at least twelve miles in this cañon. To open and work the bed of the stream, large flumes and derricks would be required to operate successfully.

But few miners have, singly or in the aggregate, money to invest in carrying on an enterprise of this character; and before they would consolidate themselves for an enterprise of this or any other kind requiring heavy outlay, they must first exhaust the more easily accessible placers, on the same principle precisely that the shallow placers were nearly or quite worked out before the hills were opened in California. The hills and bars in the cañon can never be worked until the Malheur and Burnt River Ditch Company convey water to work them. A number of low-line ditches are taken out and in course of construction on Burnt River below Express Ranch. These low-line ditches are principally built by the miners, small in size, not high enough for hydraulic mining, and seldom exceed from one to three miles in length. However, there is a ditch company incorporated, with a large capital stock, in Chicago, Mr. W. P. Richmond, president; Mr. McHenry, secretary; and Mr. Donnell, superintendent. Their object is to construct one or more large ditch from the vicinity of Express Ranch, or mouth of the cañon just named above the ranch, and convey the water down over the bars and foot-hills for sale and to mine their own land. This company would have a line of ditch that would command a large tract of valuable land for hydraulic and ground-sluicing, and their line of ditches would, or can be, extended to cover good mining land to Snake River, say forty miles.

Mr. C. W. Durkee, of Express Ranch, has also commenced a line of ditch out of Burnt River, that would be some 200 feet higher on the hills than Mr. Richmond's line of ditch. Both ditches would be nearly the same length, command the same country, with this exception, Mr. Durkee's being highest on the mountain, would command a large tract of mining land lying between the two ditches. Towering high on the mountain, above all these lines of ditches, will come in time a branch ditch from the Shasta Pass, owned by the Malheur and Burnt River Ditch and Mining Company, that will lie on the mountain-side a thousand feet higher than any other ditch can ever go; and yet high above this line lie Sutherland's mines, where, with snow-water in the spring for from four to six weeks, men make what would be in the older States good pay for a year's labor. Higher still is the far-famed Mormon Basin, situated on the summit of the mountain and near the center of all the camps named. Few camps have been found richer than Mormon Basin. I am reliably informed that one thousand buckets of dirt have yielded as high as one thousand dollars in rocking. As the supply of water in the basin is very limited, the mining population has seldom exceeded from three to five hundred persons.

There are a number of small ditches on South Powder River, which enable from three to five hundred Chinamen to make a living at mining. Messrs. McCrary, Tracy, Ingraham, and others own a number of small ditches on Rock Creek and North Powder. Some of them are five miles long. They command an extensive hydraulic and ground-sluicing district, that pays from $2 to $10 per day to the man, with good water priviledges. In the foot-hills near Pocahontas a number of good claims have been found, the gold being very coarse. One piece found last summer was worth $247. Salmon Creek, in same district, is opened in several places, and found good. Distant about thirty miles north of Burnt River country lies what are called the Eagle Creek mines, in Union County. The range and character of gold is the same as in the Burnt River country. The Eagle Creek mines have been worked with rockers for some years, and a very large amount of money taken from them in that way; now there is a ditch under construction to supply the wants of that country. The following, from the Bedrock Democrat of Baker City, gives the latest information on the subject of these mines:

"EAGLE CREEK AND ITS PROSPECTS.—For some time past we have heard it rumored that the construction of a large ditch in what is known as the Eagle Creek country was contemplated. We are now able to state that the waters of Eagle Creek have been secured, and that C. M. Foster, United States surveyor of mining lands in Eastern Oregon, has run trial-lines, and surveyed and staked out over sixteen miles of the main line of the ditch. It will be about twenty-two miles in length, and is intended to have a capacity large enough, with the aid of reservoirs, to run and sell 3,000 inches of water in the Shanghai, Rooster, and Powder River Slope mining districts. Work on the ditch will be commenced as early as April; if the weather permits, in March next. Mr. George Carter is now looking for a good site on which to cut the flume lumber, and intends to be ready for operations by the 1st of April, the amount of lumber being about 300,000 feet. It is the intention of those engaged in the enterprise to have a ditch completed and conveying water between the 1st of August and September. The

principal part of the work on the ditch will be let to two Chinamen, one of Baker City and the other of Auburn, who will put on between two and three hundred Chinamen, and finish the ditch, with ease, by the time the flumes can be built. The projectors of the work, we are assured, have perfected the financial arrangements, and will safely carry the enterprise through to completion.

"Messrs. Bowen & Cranston, of this place, are going over to select a place for a store, which will probably form a nucleus for a town in that section of the country. They will take a number one selected stock, full and complete in every department required in a new mining country. Both having had large experience as pioneer merchants of Auburn, Idaho, and Clark's Creek, they are certainly well qualified for such an undertaking. They design being ready for trade, in the new location, by or before the 1st of next April. C. M. Foster has surveyed a number of mineral land claims in that country, under the United States mineral land act—the size of them all the way from ten to eighty acres. Quite a number of claims, from ten to forty acres, have been located by some of our pioneer miners from Auburn—among them are George Slocum, D. Moore, C. E. Smith, and Judge White. The Eagle Creek country, through portions of which this ditch will be constructed, is known to be very rich in auriferous deposits; it is also extensive. In gulch, creek, flat, and hill are paying gold mines, and all now wanted is a good supply of water. When that is secured, the Eagle Creek country will be second to none for mining purposes; and it will be equal to any camp in Oregon. It is well known here who are the projectors of this enterprise; but as Portland and eastern parties desire an interest, the matter of incorporation will be postponed, but the work will be prosecuted without delay at the time specified. The Eagle Creek enterprise and mines are in Union County, and are destined to add largely to the wealth and population of that county. Union and Baker are the richest counties in Oregon in mineral resources."

W. H. Packwood and Alexander Stewart are the projectors of this enterprise. The cost of the ditch will be not less than $100,000, with reservoirs. They have a never-failing stream of water from 1,500 to 2,000 inches (miner's measure) as a source of supply. After building about eleven miles, their sales of water will amount to from $50 to $100 daily. They can sell all their water from two to five times and realize from 30 to 40 cents per inch, and it is not unreasonable to believe from what is known of the extent and character of the country that this line of ditch will repay the entire outlay in dividends in one year from its completion. A town named Sparta has been laid off in that vicinity, and buildings are being erected for stores, etc., at this time, and numbers are preparing to build.

From the article in the Democrat, you will see that miners are locating mining lands in this district under the United States mineral land act. This is the first land ever located in Oregon in that way, so far as we can learn. All mining lands have been owned by squatter, or possessory title character heretofore. In consequence of the manner of holding under the old style, men have been very reserved in the matter of even taking up, or investing money in mining lands, unless actually prepared to occupy and work the same. Representation is ever a prominent feature in the mines, and if a man has invested thousands of dollars in land and fails to represent it properly, he forfeits all title if any one should step in and represent the land.

Representing varies in different localities. Some camps require $25 in labor in the year on or for each claim owned, water or no water. Some require representing each year about the time water is expected; and if no water can be obtained for mining, notices are to be renewed on boundaries, and claims laid by. All claims require representation by actual labor on an average one day in seven when water can be obtained.

Now, under such circumstances it is not a cause for surprise that outside land—or land on which water can only be obtained at great expense—should remain unlocated or investments made to bring it into market when the title to it could only be of a possessory character, entailing through representation each year, for each claim owned, from three to four times the Government price for same. This United States law will create a revolution in title, and by doing that representation as now practiced will cease. While it is true that this law may induce larger investments in mining lands than heretofore—in some cases to the injury of the poor man—it is believed by many (aside from being a source of revenue to the Government) that an absolute security of title will induce investments of capital to improve, bring water, erect hydraulics, construct flumes, etc., on a large portion of our mineral lands that poor men could not now or hereafter operate. Should such be the result, as we are inclined to believe that it will be, it will even, while making the rich richer, benefit the laboring man and the country more than under the present practice, as then thousands can be employed in fields created solely by the aid of capital.

The yearly gold product of our mines cannot have been less than from one to one and one-half million dollars from 1863 to 1870. The gold has been, we may say, the sole product of labor. The number of miners has varied from one to three thousand, averaging for several years about fifteen hundred. The average mining season has not been three months per year. With the amount of water that can be obtained by means

of the ditches now contemplated, our mining population and gold product should be from three to five times greater than heretofore.

So far we have no more than cracked the shell of our mines, the core and heart still lying in the hills and old river-channels, and we have only been slowly but surely developing this fact. In the Blue Mountains, on the head of Grande Ronde River, good land has been found, and indications of extensive hill-mines. Good copper and coal have been found in Union and Baker Counties, on Snake River. T. J. Carter, W. H. Packwood, and Isaac and John Garrison expended several thousand dollars in prospecting for coal on Snake River. Sufficient work was done to show the existence of good coal deposits of a bituminous character; but as there was no demand except for blacksmiths' use, it would not pay them to continue work.

Our quartz interests are in their infancy. So far the Rockyfellow lode has been worked more than any other vein or lode in Baker or Union Counties. This lode has been worked for the past five years, paying, we are informed, well and regularly. The present owners, Messrs. Brown & Virtue, are down about 400 feet, have a well-defined lode from 20 to 30 inches wide. The quartz yields them from $40 to $60 per ton. The gold is worth $19 50 per ounce. The owners have a ten-stamp mill at Baker City; obtain their power to drive the mill from a ditch from Powder River. The lode is situated about seven miles from Baker, on the divide between Powder and Burnt Rivers. This lode has yielded thousands of tons of good rock, and from present indications is inexhaustible, and the mine probably contains wealth sufficient to pay for working for ages to come. E. M. White, at Auburn, is down over 110 feet on what there is every reason to believe is a true vein. The vein is almost perpendicular, with well-defined wall-rock. The rock contains fine gold. The vein is from 6 to 30 inches wide, and improves as they go down. Mr. White intends soon commencing a tunnel, calculated to tap the lode about 200 feet below the surface. He has taken out in sinking his shaft, almost beyond doubt, quartz sufficient to pay for erecting a mill, which he intends doing this summer. The rock has been worked in an arrastra, and yielded nearly $90 per ton. Quite a number of other ledges have been found in the same vicinity. Up on South Powder a number of fine ledges have been found.

Near Pocahontas a ten-stamp mill is now being erected by Messrs. Olds & McMurran, and is to do custom-work. Water, for milling, and wood, for steam, are abundant, and cheap living can be had, as Pocahontas is situated in the edge of one of the best farming districts in Eastern Oregon. Quartz is abundant in the foot-hills and mountains back of Pocahontas. Many lodes are partially opened. Some have been worked with an arrastra, some with hand-mortars, and the results are extremely favorable. In fact, the rock was so well known that I understand that Messrs. Olds & McMurran have more than rock sufficient engaged for crushing from responsible parties to pay the entire cost of erecting a mill. The Young America is about 4 feet. A tunnel is being run to strike it deep down in the hill. The Gunboat is near 2 feet wide 30 feet down, and the rock is, without doubt, extremely rich. On Salmon Creek, in same vicinity, a ledge has been found recently that 12 feet down is nearly 4 feet wide, and from which we have seen as rich rock as we ever saw from California. In Rye Valley a large number of ledges have been found in which silver predominates; so far no capital has been invested to develop them. At Hagern, Union County, a small mill is owned by George Carter and others, in connection with a number of ledges. On one ledge they are down about 130 feet with a tunnel. The vein is, in places, as much as 30 inches wide; rock is abundant; all the rock pays for milling, and in some places he has found rock that milled about $500 per ton. There are a large number of ledges found in that county that prospect well.

As I said before, no capital has been invested in Baker and Union Counties for the purpose of developing mining interests, except the amount named from Portland. Our placer and hill mines and quartz are of such a character as to require capital and labor united to develop them properly. When developed, as they will be sooner or later, they will be found to contain unbounded mineral wealth, and to be as certain, safe, and reliable counties for good paying returns on investments of that character, as can be found from Colorado to the Pacific coast. The population of Union and Baker Counties has probably never exceeded 12,000 persons, and has not, we think, been less than 8,000 since 1862. The climate of the country is healthy, equal to any part of the Pacific coast. Both counties have extensive farming land and grazing country almost unequaled, and in fact not surpassed, in Oregon or California. Both counties have been wholly dependent on Portland for merchandise, but the completion of the Union and Central Pacific Railroads has given Portland competitors for our trade in the enterprising merchants of Chicago.

Last fall a Chicago merchant shipped a fair stock of merchandise to Eldorado, and we learn he is so well satisfied with his venture that next spring he will ship a large stock to Eldorado via Kelton and Boise City. This competition will be of great benefit to the people of Baker and Union Counties. Portland having had a monopoly of our trade, we have been taxed as high, and higher on an average, for merchandise than the same sold in Idaho, from one to three hundred miles farther inland than we were

from Portland. We trust our Senators and Representatives may induce Congress to pass a bill for a railroad to connect the Columbia River and Central Pacific or Union Railroads, such as to insure its early building. Such a road would naturally and necessarily run very near the center of both counties, and would, by giving means of transportation for our products, lead to the settlement of millions of acres of land valuable for farming and grazing purposes. With such road completed, we do not know of any part of the Pacific coast that would offer better inducements to the emigrant for permanent homes than in these two counties. Nor do we believe that, with railroad facilities, any two counties in the great basin from the Rocky Mountains to the Sierras or Cascades offer to the capitalist mining investments of a more permanent character, on which certain, safe, and speedy returns can be expected. From 1862 to 1871 our imports have been paid in gold from our mines; with increased facilities for transportation we could pay in wool, flour, bacon, butter, cheese, beef, and many other articles of produce that now depend solely on the mines for a market. The gold yield should not be one million, but from three to five million dollars yearly from these two counties, and from agricultural and grazing products a like sum. The same may be said of Umatilla and Wasco Counties as to health, grazing, and farming, but their mineral resources are limited. These five counties—Baker, Union, Grant, Umatilla, and Wasco—embrace what is known as Eastern Oregon, an area of country equal in extent to many of our largest States.

CHAPTER IV.

IDAHO.

This Territory manifests a considerable decrease in its product of gold and silver, as may be seen from the following detailed estimate for the calendar year 1870, kindly prepared for me by Mr. W. A. Atlee, agent of Wells, Fargo & Co., at Boise City. Mr. Atlee has taken great pains in the preparation of this table, corresponding with all the express agents of the Territory, and perfecting his estimates slowly and laboriously. His position, experience, and intimate acquaintance with the field entitle his work to confidence.*

In this list, the production is arranged according to points of shipment.

Placerville	$184,428
Centerville	249,839
Pioneer City	250,000
Idaho City	2,000,584
Boise City	332,101
Owyhee	842,935
Lemhi County	350,000
Lewiston	702,613
Wallula	57,500
Walla-Walla	600,000
Umatilla	280,000
Loon Creek, Dead Wood, Snake River, and other diggings	150,000
Total	6,000,000

Walla-Walla, Wallula, and Umatilla are outside the boundaries of the Territory; but a great portion of the Idaho treasure finds an outlet through these places to Portland. The bullion from these points, together with that from Lewiston, making altogether some $1,790,000, is included in the express and private shipments from Portland.

The decline in the production of Idaho is due to the exhaustion of the creek and gulch claims of the older placer-mining districts of the Boise Basin. The greater portion of these claims have been turned over to Chinamen, who are content with small earnings, and who will maintain, no doubt, for many years to come, a moderately productive industry in these abandoned fields. Many experienced miners express the opinion that the ground in creeks and gulches which has been worked over already has since accumulated a second crop, as it were, of gold. This is doubtless true of certain peculiarly situated localities; but such a rapid regeneration of mining ground cannot be predicated on a large scale. As Mr. Atlee remarks, however, in a letter to me on this subject, many patches of auriferous earth and gravel, rich in gold, were passed over undisturbed by the early miners; millions of cubic yards of sur-

* It will be observed that the estimate of $8,000,000 for 1869, credited to Mr. Atlee, on page 234 of my last report, was reduced by me to $7,000,000. Certain items in that estimate were assumed, and I therefore took the liberty of altering the total. The present estimate is carried out in greater detail; and I accept it as the best possible.

face material have been "stripped off" in search of the best "pay dirt;" vast amounts of auriferous earth have been sluiced from hill-sides and side-gulches into the main streams, and the accumulations of *débris* from all these sources have been exposed to disintegration and concentration under the action of the elements and the flowing water, constituting new deposits, which can only be exploited by means of bed-rock tunnels and flumes.

The quartz-mining industry has made little progress outside of the Owyhee district. Unwise and sometimes dishonest speculations have led, in Boise and Alturas Counties, to a distrust on the part of capitalists; and to this evil influence must be added the disadvantage of geographical position with reference to the railway communication, which has added so many facilities for the development of districts more favorably situated. When the difficulty and cost of obtaining communications, machinery, supplies, and labor were felt in common by all the mining regions of the interior, they operated with less discrimination against particular localities. Now that a portion of the country has been relieved from this burden, the crying necessity is everywhere realized. "What we require," says Mr. Atlee, "is railroad facilities."

Brief notices of such districts in the Territory as seem to require particular mention will suffice to complete this general statement of its condition and prospects.

OWYHEE COUNTY.

The placer-mines of this county have been diligently worked during the past two years by the Chinese, who have operated hydraulic claims as well as ordinary placers. Four hydraulic mines are reported as worked by white men. Three of these were old claims. The fourth is a claim about half-way up the side of Florida Mountain, near Silver City. Water has been brought by a ditch, four and a half miles long, constructed in the autumn of 1869, from the head of Jordan Creek. The product of one hydraulic claim was nearly $20,000.

The product of the mines of Owyhee district for the year ending July 1, 1870, was as follows:

Mines, etc.	Amount of ore.	Product.	Yield per ton.
	Tons.		
Ida Elmore	5,396	$239,109	$44 31
Mahogany	507	32,551	64 20
Golden Chariot	3,943	236,624	64 62
Slimes and tailings	1,462	14,620	10 00
Poorman	1,600	42,769	26 73
Allison	124	6,274	50 60
Red Jacket	(?)300	13,993	(?)46 44
Prospecting, etc	(?)650	37,625	(?)57 88
Total quartz	13,982	623,565	
Placer gold	....	51,541	
Total bullion product	....	675,106	

Average from quartz, (principally silver,) $44 59.
Average, omitting slimes and tailings, $48 64.

The item of "prospecting" in the foregoing table includes the operations of many parties with little capital, who bring in from time to time

small lots of ore to the mills. Under this head is ranked also the product from Flint district, where, perhaps, twenty men have been at work slowly developing some of the lodes of "fahl-ore." The results have been highly encouraging, considering the scale of operations. Some of the rock crushed has yielded $200 per ton.

The slimes and tailings reported in the table were worked at the mill of the Owyhee Mining Company, which treated more than half of the aggregate amount of ore reported, or 7,129 tons out of 13,982. The tailings, however, were from a pile some four years old. The slimes or slums are collected from the battery-waters in separate reservoirs, and subsequently are mixed with dry tailings to give them the necessary consistency for reworking. This is the only mill in the district having reservoirs for slimes alone. The cost of working the slimes is $5 per ton.

The amount of ore worked during the year referred to is nearly 1,000 tons in excess of that reported for the previous year ending July 1, 1869, while the bullion product is about $375,000 less. This falling off is due to the decrease in bullion from the Golden Chariot, Ida Elmore, and Poorman mines, amounting to $373,000. On the other hand, the closing of the Rising Star mine, in Flint district, and the cessation of bullion from that source, is almost made up by the increase in placer-gold and the yield of other lodes.

The Ida Elmore looked badly during the first part of 1870, and in the autumn an assessment of $50,000 was levied. At the close of the year, however, a considerable improvement was manifest. The product of the mine during the calendar year 1870 was $238,532.

In the Golden Chariot mine, work has been pushed with vigor. About the 1st of July, 1869, the ore began to depreciate in value, and for the months of August, September, October, and November of that year showed an average yield of only $40 per ton. Then a new level being opened, much richer ore was exposed, and this good quality has been maintained ever since. The lowest level in December, 1870, was 470 feet below the surface, and showed a splendid vein, three feet in width, of very good ore. Mr. Cassell, formerly in charge of the Oaks and Reese mine, in Mariposa County, California, is now superintendent of the Golden Chariot and Ida Elmore. He has introduced Giant powder and the single-hand drill, on the system described in my report of 1869, page 33. Without repeating the account there given, and the estimates of advantage attached to the system, it is sufficient to say, on Mr. Cassell's authority, that he has taken out from the Golden Chariot and Ida Elmore twice as much ore for the same amount of openings as was formerly done with common powder and large drills, while the cost of mining has been reduced at least one-third. All the leading mines of the district, following this wise example, now employ single-hand drills.

The secretary's report for the year ending February 1, 1870, gives the following information in regard to the business of the Golden Chariot:

Receipts from bullion	$279,381
Bills payable	24,044
Other items	34,716
Cash on hand February 1, 1869	34,716
	372,857
Expenditures	339,559

including $109,503 for labor; $17,334 for supplies; $61,286 for milling; $14,895 for hauling.

The quantity of ore milled was 3,767 tons, the yield of which was $71 50 per ton. The supplies consumed during the year cost $12,006. A balance of $33,000 was paid on a mortgage for an adverse title. There were three dividends paid during the year, aggregating $80,000.

The bullion receipts of the Golden Chariot for the calendar year 1870, as compiled by Mr. R. Wheeler of the San Francisco Stock Report, have been as follows:

January	$25,138	August	$50,606
February	35,055	September	64,616
March	21,846	October	78,576
April	....	November	76,187
May	18,566	December	76,277
June	18,566		
July	18,566	Total	483,999

Of the less productive mines the Red Jacket and the Mahogany have furnished excellent ore. The vein of the former is said to be small and very hard, but rich. The Mahogany vein is reported to be both wide and of good quality, but for some reason the company has been forced to lay an assessment. The Red Mountain, Chipmunk, Corduroy, Peck and Porter, Blue Jacket, and Belle Peck have produced ore. The Poorman mine has been closed; probably for good, as all available ore has been extracted, and there is little apparent encouragement for further prospecting. The Owyhee Company, owning this mine, has been for some years occupying itself largely with custom-milling, and looking about meanwhile for a mining property. The company worked the Allison mine for a while on lease, and it turned out some very good ores, resembling those of Reese River, in Nevada, more nearly than any other Owyhee ores which I have seen; but their occurrence in spots necessitated the extraction of much barren rock, and the mine was closed, as the expenses exceeded the receipts. The Owyhee Company subsequently purchased the Oro Fino mine, and work has been commenced upon it. This mine, under its former owners, was highly productive and profitable. The Oro Fino is probably the strongest vein in the district, and carries large amounts of fair mill-rock. Litigation only has prevented its working for several years past; but it has now fallen into skillful and energetic hands, and will be again an important producer of bullion.

At the close of 1870, seven mills were running with tolerable regularity in Owyhee County, as follows: Owyhee, 30 stamps; Ida Elmore, 20 stamps; Cosmos, 10 stamps; Webfoot, —— ——; Shoenbar, 5 stamps; Minear, 3 stamps; Black's, (in Flint,) 5 stamps. There were also two arrastras constantly running, and a mill nearly completed at Fairview. The milling capacity of Owyhee district, leaving out the Rising Star, Black's, and Iowa Mills, in Flint, is about 3,500 tons per month, and this production will probably be maintained by the mines through the summer of 1871. The product of the latter half of 1870 was much in advance of the previous half year, amounting to more than 9,000 tons; and the bullion production has increased in proportion. The exact figures have not come to hand, but I learn that the bullion shipments during the last six months of the year 1870 were more than two-thirds of the whole product of the preceding twelve months. Reckoning for the calendar year 1870, the product of Owyhee County, according to the figures of Mr. Atlee, given on a foregoing page, was $842,935.

THE BOISE BASIN.

Water was tolerably plenty in the basin during the spring and early summer, and the yield from the placers was, perhaps, better than in the last two years, when the failure of the winter-snows left the spring without a steady supply of water. But the sanguine hopes of many who looked for a large increase in the bullion production of the basin have been disappointed. The fact is that new fields of mining nearer the railroad are draining Idaho of her nomadic mining population, and leaving the diggings in the hands of fewer men, who, though they may do better individually than heretofore, do not produce so much in the aggregate.

Nevertheless, it must not be inferred that the placer-mines of Boise are exhausted. They still produce a large portion of the bullion yield of the Territory, as may be seen by reference to Mr. Atlee's table, at the beginning of this chapter, in which the shipments from the first five localities named are to be ascribed chiefly to this source. It is here, moreover, that single claims are reported as yielding the largest sums. Of sixty-four placer-claims in Boise County, reported to the Census Bureau, employing four hundred and seventy-one men for an average period of 4.15 months, at average wages of $73 per month, the aggregate yield was about $360,000, or $7 per day per hand. This list of claims includes a portion of those at Granite Creek, Placerville, Idaho City, Boise, and Centerville. The highest yield from any one claim is $29,000, and there are a considerable number ranging from this sum down to $10,000—about 20 per cent. of the claims reported producing each $10,000 or more.

The growth of quartz-mining is the natural compensation for the decline of the placers. Aside from other characteristic differences between these industries, there is one which has not been sufficiently weighed. Quartz-mining is not only more permanent than placer-mining; it is more productive for the number of men employed than the average placer-mining. But the expenses of materials, machinery, and skilled labor are heavier, so that this form of mining must develop later and more slowly than the irregular pioneer activity of the gulches and diggings. In Boise Basin, the vast extent of placer-ground is, I hold, a certain indication of resources which will some day be exploited by deep mining. But little has been accomplished in this direction, during the past year, in this part of the Territory.

The Elkhorn Mill, in Boise County, was reported to be idle. One or two enterprises at Granite Creek, which appears to be the most active quartz-mining camp in the county, have been moderately successful. The following account of this locality is extracted from the correspondence of the Scientific Press of San Francisco, dated June 30, 1870:

The Gold Hill mine and mill are situated on Granite Creek, about three miles from Placerville. The ledge runs northeast and southwest, has an easterly dip, and crops out boldly for over half a mile. The average width is 3 feet. The company has been vigorously at work for years, and has one 80-foot, one 120-foot, and one 100-foot shaft, and three very large tunnels, all on the ledge. We entered first the lower level or tunnel, passing along 450 feet to where the ledge was tapped. We then went in the left drift on the lode, a distance of 80 feet, and here found the ledge about 3 feet wide, and heavily charged with sulphurets and free gold. Returning to the tunnel, we find another drift, some 80 feet long, on the ledge. At the entrance of the tunnel is the mill, which is therefore very conveniently situated with regard to the mine. When winter sets in the company will drive a shaft up to the second level, and eventually bring all the ore out through the lower tunnel. At present the ore is lowered down an incline from the second tunnel. This incline is some 400 feet long, and is 350 feet farther up the creek. On it a 1-inch wire rope (manufactured by Hallidie & Co.) is

used, and the loaded car going down hauls up the empty car. At this mine are employed some thirty miners, who are paid $75 (currency) and found.

On both sides of the creek we find a granite formation, in which are the veins of quartz holding gold with silver and sulphurets, the gold predominating. The ore resembles somewhat that of Grass Valley. There were no sulphurets on top, those being first reached at a depth of 60 to 75 feet. The superintendent of the mine is Mr. David Coughanour, a very clever and enterprising gentleman. The mine has paid expenses of all kinds.

The mill was erected by the Chickahominy Company at an early day, at a cost of $75,000; but the present company bought it at a low price not long ago. It has twenty-five stamps, of 850 pounds each. To each four stamps there is a Hungerford concentrator, which does very well, I am informed, and gives satisfaction. A Hendy concentrator, also four large Wheeler pans, and two large settlers, are used. The engine is of 75 horse-power, with cylinder 36 by 14 inches, and was built by the Miners' Foundry of San Francisco; the two large boilers were made by the Coffee & Risdon Works. Three and a half cords of wood, costing $4 per cord, are burned daily. Twenty stamps were in operation at the time of my visit, but the other five were soon to be set at work. Some 35 tons are now put through in twenty-four hours. A clean-up, while I was there, of nine and a half days' run, gave 55 pounds of amalgam, which yielded $6,000. On account of the sulphurets, only about one-half of the gold is extracted from the ore. The company has now on hand some 300 tons of sulphurets, and they are taking steps with regard to introducing Kustel's process for working these. The mill is owned by Thomas Mootrey, jr., William Lynch, and others.

The western extension of the Gold Hill mine is owned by Chandler & Co., who have a tunnel in some 40 feet on the ledge. The vein is from 1 to 3 feet wide, and contains good ore, giving upward of $30 per ton in the mill.

The Eastern Extension, popularly called the Growl and Go Ledge, is owned by M. and J. Eissler. The shaft is down about 35 feet, being all the way in decomposed matter, the sulphurets not being yet reached. The company talk of erecting a ten-stamp mill near that of the Gold Hill.

The Yellow Jacket mine, located half a mile up the creek, is owned by C. P. Emery, G. White, J. Dixon, and others. The lode runs northeast and southwest, and averages 2 feet in width. The tunnel is in 170 feet. The rock contains principally free gold, but they expect to find sulphurets as they go deeper. The ten-stamp mill is now being built, and will be running in a few weeks.

The May Flower mine is a fine-looking location owned by Turner & Young. The vein runs northeast and southwest, and averages 3 feet in width. There is a tunnel 250 feet long; also, a shaft 90 feet deep. The boys have been working three years and doing well, and it would pay to have a mill here if the owners of the mine were able to build it. They have been working their ore successfully for three years with an arrastra. The apparatus for revolving the stones is quite unique, being a horizontal hurdy-gurdy wheel, 24 feet in diameter.

Besides these mines there are several others, as the Gray Eagle, Columbia, Web-Foot, Lawyer, Pioneer, Golden Gate, etc., which I was unable to visit. One fact particularly struck me here, and that was the abundance of timber close to the mines.

The same writer describes as follows two mines in the neighborhood of Centerville:

Twelve miles east from Centerville, on Grimes Creek, is the lode of the Mammoth Gold Mining Company, located in 1863. The average width of the lode is about 2 feet. The vein-matter contains free gold and sulphurets, and the ore generally averages $50 per ton. I find that last summer there were 200 tons crushed, which yielded $90 to the ton. There is a shaft sunk 160 feet on the ledge, and a tunnel some 300 feet long, which strikes the vein at a distance of 150 feet. The company has an eight-stamp mill, run by water-power, built in 1865, which cost some $8,000. The mine has paid all expenses. The owners are Clarkson & Brown, old pioneers of this district.

Four miles farther up the creek is the King Company's ledge. This vein is small, but very rich and with well-defined walls. There is an eight-stamp steam-mill here, but I understand that not much work is being done at present. Want of time prevented my visiting this place.

These extracts, which might be still further multiplied, will suffice to show that in the great placer-mining region of Idaho there is an underlying basis for permanent mining, which will be developed as the superficial industry declines and commercial conditions improve into a steadily productive source of wealth. From this point of view, encouragement is to be found in the diversion of labor for the time being to farming and stock-raising, and in the increased prosperity of those pursuits. "The

grain, hay, and vegetable crop of Boise and other agricultural districts," says the Boise Statesman of July 1, 1870, "is better than ever; and a confidence is felt among that portion of our community that has never existed before. As the placer-mines decline, persons forsake them for the more permanent pursuits of farming and stock-breeding, and in the end the country will undoubtedly be the gainer. Several droves of cattle for breeding are coming into the Territory, one man alone, in the Raft River country, receiving an accession of three thousand head. Another has just started in the same region with fifteen hundred, and the Bruneau and Weiser Valleys are constantly receiving additions of settlers who propose to permanently engage in farming and raising stock."

The United States assay office at Boise will be put in operation in July, 1871.

THE BASALTIC CAÑONS OF THE COLUMBIA AND ITS TRIBUTARIES.*

During the last two years it has been my lot to travel upward of twenty thousand miles in various directions across the States and Territories of the inland basin and Pacific slope of this continent. The object of these journeys was primarily connected with the gold and silver mines upon our public domain, and such observations as I was able to make of a general scientific character were necessarily incidental, rapid, and superficial. They are not offered as contributions to exact and detailed knowledge, but rather as suggestions, the value and interest of which will doubtless vanish in the light of more careful investigations, but which may, for the present, be useful in awakening attention, and furnishing a broad, general outline of certain great natural features not yet universally familiar to the public.

Indeed, while the defects of hurried observations during rapid and extensive journeys are sufficiently obvious, they may be said to possess, nevertheless, a certain advantage in facilitating the formation of comprehensive views on the large scale. The close and minute study which is necessarily bestowed upon details, by the votaries of every natural science, is not always favorable to generalizations and wide comparisons. The slow accumulation of facts which forms the essential foundation of science is not itself science. Its tendency is toward the exaggeration of differences rather than the recognition of similarities. Under the magnifying lens of the close observer, the smallest phenomena become important; and while one eye is at the microscope we cannot see things in their true proportions with the other. A clerical friend once remarked that in addition to his ordinary readings of the Bible by chapters or texts, he was accustomed occasionally to peruse a whole book at a sitting, in order to gain, what he was likely to lose in minuter study, the sense of general scope and spirit. In like manner, I venture to think it is well for us to turn now and then from the texts of nature and read with freer glance and wider range her gospels and epistles, to leave for a while her sentences, fine-graven on stone or leaf, and skim her ponderous volumes, bound in continents and margined by the sea.

The illustration may be applied in another aspect. As the Bible consists of many books, of different ages and human authorships, yet all constituting the one Revelation, so each of the natural sciences comes to its full revelation by successive contributions. This is especially true of physical geography and geology, two sciences which have not yet reached the stage of general formulæ—two Bibles, of which all the books have not been written. Each country seems to have a new aspect of the truth to present, enlarging and modifying the whole. Thus we have had a geology founded upon the carefully studied phenomena of a small section of Europe. A new era in the history of that science was opened by the work of the British survey and the rise of the British school of geologists. In this country we have had an American geology based on the microcosm presented by the States of New York and Pennsylvania. In all these different geologies, the presence and activity of the same dynamic agents are recognized; but the relative importance assigned to each naturally varies. And the scientific world now looks to the unexplored regions of America, Asia, and Africa to furnish the necessary corrective equations before the final formula can be evolved.

It seems to me that the regions west of the Rocky Mountains have something important to tell us in dynamic geology. A general survey leads to the impression that their most prominent features illustrate two points. They present to us vast areas in which we can study, perhaps better than anywhere else on the globe, the effects of aqueous and solfataric metamorphosis of rocks; and they offer in equal extent the

* The substance of this account was contained in a paper presented to the National Academy of Sciences, and subsequently, in its present form, in a lecture before the American Geographical and Statistical Society of New York, in the spring of 1870.

proofs and illustrations of direct eruptive agencies. The State of Nevada is a type of the former class, and the immense basaltic overflows of California, Oregon, Washington, and Idaho represent the latter.

The route traveled by me in 1869, from Sacramento overland to Portland, Oregon, thence up the Columbia to the Dalles, thence (after a brief excursion northward into Washington Territory) southwest, across the valley of the Des Chutes, up the valley of the John Day, through the mountains to Powder and Burnt Rivers, and the Snake River, up the valley of the Snake, thence to Boise City, and, finally, from Boise southward to Salt Lake, afforded views of many of the striking characteristics of this basaltic formation; and it will be my attempt to notice some of these in arbitrary order, rather than to present a complete and logically connected account of so large a subject.

All the streams I have named are part of the system of the Columbia. A word or two concerning the relation of this system, or rather of the Snake River half of it, to the structure of our inland basin. As Professor Newberry, in a recent lecture before a sister society, has interestingly shown, the physical history of the country west of the Rocky Mountains may be divided into several stages. At first the waves of ocean washed the feet of the Rocky Mountains. Then, by the uprising of mountain ranges between, the salt tides of the interior were shut off from the parent sea, to which they could return only by way of the great rivers which ran northward and southward around the ends of the new barrier. Continual rain-fall and drainage soon freshened these inland waters, and the continent, at this period, presented the spectacle of the largest expanse of fresh-water lakes ever existing, so far as we can discover, in the history of the globe. This state of things obtained on both sides of the Rocky Mountains, though I will not here discuss the question whether the fresh-water deposits on both sides are absolutely contemporaneous. Certainly those of the east were not inferior in extent, and the great lakes which still remain, drained by the St. Lawrence, though quite insignificant compared with the system of which they are a relic, may serve to give a hint of its grand proportions.

The fresh-water sea west of the mountains was subjected to yet other changes, which did not take place in the east. A further rise of the mountain barriers cut off in many places the river drainage, leaving isolated lakes with insufficient outlets or none at all; and these, by virtue of the constant influx of waters, impregnated with saline matter, and the constant concentration caused by evaportion, soon became salt. Thus, what were the briny deeps, after masquerading for a while as fresh waters, reasserted their hereditary character, and appeared as briny shallows. Meanwhile the rivers themselves put an end to the greater part of the lakes by carving deeper and deeper channels or by breaking suddenly through rocky dams, and thus draining to the bottom the inland reservoirs. This process was carried out by the Missouri and Arkansas in the east, the Rio Grande in the south, the Colorado in the southwest, and the Columbia and its tributaries in the northwest. The valleys of all these rivers indicate clearly the progress of erosion, gradually deepening the channel. It is most strikingly illustrated in the cañons of the Colorado and the Snake, while the passage of the Cascades, through which the Columbia rushes, "short-lived and jubilant," to the sea, is probably an instance of the overcoming of a barrier, letting out, in an instantaneous flood, the mass of waters behind.

The present appearance of the inland basin is that of an elevated table-land, corrugated with mountain ranges, and divided into meridional valleys, each with its own isolated water-system. The disappearance of the vast bodies of water that once covered its surface has greatly altered the climate, diminishing the rain-fall, and transforming the greater part of the region into a desert. What rain it now receives must come from the Pacific, and the supplies from this quarter are intercepted, first by the Coast Ranges and then by the Sierra, so that the "leavings," distributed over the vast table-land, are quite insignificant; over the whole surface ranges, in perpetual winds, a dry and thirsty air licking up with amazing rapidity all exposed moisture. The streams that rise in the mountain ranges, and flow downward into the valleys, soon disappear—partly absorbed in the sandy soil and partly (indeed, chiefly) taken up by the atmosphere. Even large rivers, like the Humboldt, spread out into shallow lakes, erroneously called "sinks," and, exposing thus a large area to evaporation, dry up. Reese River flows northward for a hundred and fifty to two hundred miles, through a narrow valley, where it is frequently replenished by smaller tributaries; and, after this long journey, having almost reached the Humboldt, it pauses and is lost, dying, like a weary pilgrim, in sight of the shrine. In the immediate neighborhood the Carson River also has its sink.

The amount of water in these isolated streams and basins depends upon the fluctuating balance between rain-fall (or snow-thaw) and evaporation. This is curiously shown in the little system of the Truckee. This stream—a turbulent river—is the outlet of Lake Bigler, a beautiful mountain lake, situated among the summits of the Sierra, and fed by their melting snows. The Truckee flows north for a dozen miles along the range, then pitches downward and eastward, through the pass traversed now by the Central Pacific Railroad, into the Nevada basin. Here it turns again at right angles

to the north, and, flowing a score of miles, empties into Pyramid Lake, which constitutes its sink. Bigler is fresh, Pyramid is salt; Bigler has no inlet, Pyramid no outlet; and from Bigler to Pyramid flows ever the swift Truckee. The snows of the Sierra thus find their way into the lower basin, to be thence taken up to fall again as snows—I had almost said—upon their native peaks; but the "circuit of Nature" is not in this case so prettily completed; since the evaporations of Pyramid Lake are doubtless carried by prevailing winds to the east, to be precipitated, perhaps, on the rim of the basin of Salt Lake. It is evident that the change of level in one of these isolated lakes affords us a measurement with regard to the relative rain-fall and evaporation, provided the absence of drainage be ascertained. The Salt Lake is hundreds of feet lower than it once was; the former lacustrine beach can be distinctly traced, like a high-water mark, along the mountain-sides. But this great change of level is doubtless due to sudden drainage rather than slow subsidence of the water. Since the Mormons settled the country, the lake is said to be rising, and to have submerged already much land that was formerly dry the year round. This may, however, be but a temporary fluctuation.

The Salt Lake basin is separated by so narrow a divide from the system of the Snake River as to render it quite probable that this stream once drained it—that is to say, that the basin formerly spilled over its rim into the Snake river. This part of the country, or rather a region a little north and east, includes a curious nodal point, as it were, from which the headwaters of the Snake and the Colorado and the Missouri take their rise, and flow in different directions to the sea. It was near here, in the Wind River Mountains, that Frémont planted the Stars and Stripes upon what was supposed to be the highest point of the continent. Lewis and Clarke, who, in the time of President Jefferson, ascended the fork of the Missouri which still bears his name, bestowed by them, found two springs, but a short distance apart, which contributed their waters, the one to the Pacific and the other to the Atlantic. The former may be considered as the source of the Lewis River, now more commonly called the Snake. From this point it pursues a devious course to the southwest, then north, for perhaps nine hundred miles, until, having been strengthened on the way by its tributaries, the Owyhee, Boise, Sweetwater, etc., it joins with the northern fork of the Columbia, to make one of the stateliest rivers of the world.

The cañons of the Snake are little known. Lewis and Clarke did not follow down this stream, being deterred by the forbidding nature of the country, which was destitute of food. The geography of the region being then wholly unknown, they were endeavoring to strike the headwaters of the Columbia, in order to follow it down to the infant settlement of Astoria; and finding no salmon in the upper course of the Snake, Lewis acutely inferred that either there were great falls in this river, or it did not belong to the Columbia system. The former of these suppositions was true; and Lewis may be said to have seen with the eye of faith the great falls of the Snake. Recrossing the continental divide and turning northward, these bold explorers finally reached their destination by an easier route. Frémont subsequently descended the stream farther than they had done; but he likewise abandoned its course, striking northward for a more favorable line, and apparently just missing by a few miles the sight of the great falls.

Like the cañons of the Colorado in the South, the channels of the Snake and other rivers of this region are carved by the streams themselves deep into the face of the country, leaving a general table-land above. The Colorado seems, however, to have had easier work, by reason of the softer nature of the predominant rocks. The characteristic formation of the Snake and the Columbia above the Cascades is basaltic—the product of vast lava overflows. The sublime group of mountains in Oregon and Washington, which includes Hood, Adams, St. Helen's, Regnier, and Baker, with others scarcely less magnificent, is volcanic. Some of these peaks have been in active eruption within recent years; and all are known to have been so at some former period. But we have not to look for volcanic craters as the centers of the great lava floods which covered so much of Northern California, Oregon, Washington, and Idaho. These craters are scattered along a distance of five hundred miles in the Cascade and Sierra ranges, but it seems probable that a line connects them, upon which the eruptions of melted lava took place abundantly, repeatedly, but perhaps more silently than is apt to be the case with the explosive phenomena of volcanoes. A plutonic dike may be traced along the Sierra, and is asserted to have been observed in a considerable sectional exposure in one of the deep side-cañons of the western slope. If we are yet ignorant of the geological history of these phenomena, it is merely because we have not yet had time to collect and compare observations. There are few regions on the globe where the handwriting of nature is larger, plainer, or less obscured by nature's own subsequent efforts to erase it. Geologists who have painfully endeavored to find in railroad cuttings, wells, or rare accidental exposures, the view of the structure of the rocks which forests and alluvion otherwhere concealed, will appreciate the ease and satisfactory character of reconnaissances in a wilderness, where the mountains are bare above, and cloven with cañons that reveal their very hearts.

One of the first things that strike the observer in these basaltic layers is their great aggregate thickness as well as superficial extent. This is finely shown just above the Dalles and in the cañon of the Des Chutes. For a considerable distance along the Dalles, the banks of the Columbia present a low volcanic escarpment, like the Palisades of the Hudson, but absolutely barren. At some points, however, the whole thickness of the mass through which the river has carved its way stands revealed. It presents to us a series of overflows, each spreading out horizontally, and succeeded after an indefinite interval by another. The aggregate thickness, as shown in the Des Chutes, cannot fall short of 2,000 feet. In different localities it is easy to distinguish between the layers that have cooled under water (*i. e.*, those which were erupted before the disappearance of the great inland lakes) and those which have congealed under exposure to the atmosphere. Possibly a still more important clew to the geological history is found in the fact that these basaltic layers inclose intercalated series of sedimentary strata. At Dalles City a bed of lava overlies a bed of conglomerate, and is in turn overlain by deposits of tufa-sandstones and clays, containing the most delicate plant-fossils that can be conceived. There are leaves, twigs, and buds in the greatest perfection. Perhaps they were brought down by the river in former times. It certainly seems less likely that they should have grown where now they are found. The mud and ashes constituting these intercalated beds may also have been erupted, since we know that nearly or quite all of the volcanic eruptions include the expulsion of vast quantities of ashes and hot water.

At the Cascades of the Columbia, the Des Chutes, and other rivers, not too much obstructed, salmon are speared or hooked in great abundance by the Indians. These fish find their way for more than a thousand miles from the sea, continually pressing up stream, and growing weaker, thinner, and more battered and lacerated by the rough and rocky trip. Those caught at the mouth of the Columbia are in far the best condition; and it is from this place that the great quantities are taken for packing and shipment to market. The Indians, less fastidious, catch their fish wherever it is most convenient, dry it in the sun, and preserve it for winter food.

Passing southeast from the Dalles, and crossing the valley of the Des Chutes, we come into the valley of the John Day's River. The walls of this cañon are of volcanic, sedimentary character, at least in many places, consisting of tufas and sandstones from volcanic materials. The effects upon these soft materials of atmospheric and aqueous agencies have been picturesque and curious in the extreme. At one point a complete ancient castle is perched, like the stronghold of a Raubritter of the Rhine, upon a commanding crag, from which its dwellers might look far up and down the valley. A little further on, a whole city, with towers and roofs of fantastic, quaint variety, attracts the wondering gaze. It is difficult, sometimes, to realize that these appearances are but the freaks of water, gnawing away into such fanciful forms the yielding layers of rock.

A brief trip into the forests of Washington Territory, up the valley of the White Salmon, and nearly to the foot of Mount Adams, gave me an opportunity to study one of the most remarkable features of these basaltic formations, namely, their subterranean passages or caves. I have elsewhere* given some account of these; but I must beg your indulgence for a condensed description here.

The whole country in the neighborhood of Dallas is covered with basaltic overflows, intercalated here and there with beds of tufa, cemented ashes, and even altered clays, in some of which interesting tertiary fossils, both of plants and animals, have been discovered. Rev. T. Condon, of Dallas City, a naturalist, whose enthusiasm, patient industry, and wide acquaintance with this part of Oregon entitle him to a fame which his modesty has hitherto avoided, has brought together a large and interesting collection of these fossil remains, which he exhibits and explains with great courtesy to his friends, among whom, with catholic liberality, he appears to reckon all those who make demands upon his time and manifest interest in his pursuits.

It is in these basaltic overflows, not more than twenty miles from the base of Mount Adams, and in the heart, so to speak, of the Cascade Mountains, west of the valley of the White Salmon River, that a series of caves occur, some of which present the phenomena of perpetual ice. Nature continues the manufacture, and stores the product, year after year, though it is but occasionally that man, exhausting his own resources, falls back upon her forethought and bounty.

The "caves" are all old lava channels through which the melted matter flowed, after the crust had cooled and hardened overhead. The same thing may be seen on any volcano; but in most cases, I presume, the molten current gradually clogs and fills the duct, and cooling leaves the solid mass. If by any cause, however, the lava should be choked at the source of the stream, I fancy that the portion already in the duct, protected to a great degree from cooling by the solid wall above and on either side would continue to flow for a considerable distance, and leave an empty space behind it. These ducts may be traced for several miles. The ground reverberates hollowly under

*Engineering and Mining Journal, vol. viii, No. 13, page 194. Overland Monthly, November, 1869.

the horses' feet; and at frequent intervals, where the crust has broken through by its own weight, the descent may be made over great blocks of basalt into the subterranean glooms. We explored one passage for a distance of 750 feet, and found the fissure still continuing at either end, though too narrow to admit of farther penetration. But two or three of these caverns have been found to contain ice; and of these only one seems to afford it in abundance and in accessible position. This one we thoroughly examined, and found the subject, upon closer attention, divested of much of its mystery.

To make an ice-cave it is necessary to have a cave. This, as we have seen, is provided by the geological formation of the locality. The next requirement is a communication between the cave and the outer air, giving opportunity for the refrigerating draughts of winter. Finally, a slow percolation of water into the cave, which may freeze solid, in successive layers, throughout the winter. In summer the ice thus accumulated thaws slowly under the influence of warmer air entering the cavern; but the thawing at one end produces a low temperature at the other, which preserves the great body of ice. Besides, it is a well-known fact that ice formed at very low temperatures will last much longer than that which has been barely frozen at 32°. Hence the amount of heat that would liquify river-ice only brings the cave-ice up to the neighborhood of the freezing-point. We satisfied ourselves, however, that the ice in the cave does thaw in summer, and the water finds its way out by subterranean channels.

I am strongly inclined to see in these peculiar lava-ducts an explanation of the phenomenon, not unfrequent in this region, of "lost rivers." We camped on the excursion to the ice-caves by the side of a brisk, musical stream, which afforded us an abundance of water for our horses and ourselves. Mounting the next morning and riding away, we were surprised to find the bed of the stream less than a dozen rods below our camp perfectly dry. A closer examination showed that the water disappeared into one of the subterranean passages in the basalt. Somewhat similar must be the course of the great "lost river" which bursts out of the vertical side of the cañon of the Snake—a torrent from the solid rock; a foundling rather than a lostling, since it is the origin, not the fate of this river which is unknown. Above its strange headlong emergence from imprisonment, the black, barren desert stretches for scores of miles, treeless and waterless. Somewhere to the northward a river has been lost, and here it is. Identified it will be, so soon as its disappearance shall sufficiently interest any of its friends to make them answer the advertisement of its discovery.

The main cañon of the Snake River is cut through basalt for several hundred miles, and in following its course, by riding along the precipitous edge of the chasm, at the bottom of which flows the river, one has excellent opportunity to study both the successive deposition of the layers of basalt, with the signs of intermittence and intervals of rest, and the peculiar columnar structure, perpendicular to the planes of deposition, of each separate layer. Not even the noted example furnished by Fingal's Cave could surpass the illustrations afforded in many places by the columnar basalts of this region. The columns are usually six-sided prisms, though sometimes they have five or four sides. This variation, however, is enough to show that the cause of their formation is not analogous to crystalline force. The form of the regular pentagon does not occur in any crystalline form; nor does nature ever confound in the same substance the hexagonal and the tetragonal forms. Probably the shape of these prisms can be explained by a less difficult hypothesis. The cell of the bee, you will remember, is hexagonal in section, and was formerly cited as a wonderful example of geometrical instinct, since it possesses exactly the form which can be mathematically proved to occupy the space of the hive most economically, leaving no wasted interstices, and consuming a minimum quantity of building material. It is now seen that the cell of the bee is spherical in shape, and assumes this economical shape under pressure. It is probable that an analogous result is due in the cooling of basalt to the pressure of the whole mass. The tendency, apart from this pressure, would be to cool in globes; but the vertical pressure converts these into cylinders, facilitating at the same time vertical cleavages through the mass; and finally the lateral pressure through the half-solidified mass modifies these cylinders into prisms. It is natural that most of these should be hexagonal, because a circle can be tangent to six other circles of equal size, and these tangent each to each; and the transformation of these into hexagons would exactly fill the surface. But local disturbances, differences in the size of the circles forming the bases of the basalt-cylinders, and other accidental causes, would naturally lead to the formation of imperfect prisms, or such as had not their full complement of six sides. And this is the exact state of things as revealed by observation. The hexagonal type seems to be predominant, but not universal.

The size of the prisms or columns is not great—seldom exceeding one or two feet as the width of a side. Although the horizontal divisions between successive layers of basalt indicate long periods, possibly, of intervening time, and we can therefore not expect the columns to be continuous through the different layers, yet this is sufficiently the case (*i. e.*, the cleavage planes between the prisms in one layer coincide sufficiently well

with those in the layer below) to permit extensive vertical cleavages of large masses of basalt, from the surface down through a dozen layers, to the very bottom of the cañon. I have stood above, with one foot upon the solid basalt, and the other upon the upper edge of a narrow slice thus parted from the main body, while between my feet a deep, long crevice, only a few inches in width, extended down to the base of the cliffs, giving me a glimpse of the river hundreds of feet below. The manner in which the cañon of the Snake appears to have been enlarged is by the gradual wearing away of the base of its walls by the flowing river and the grinding boulders, and then the toppling or sliding off of these massive slices from the whole face. The walls remain almost everywhere vertical, and the swift stream below carries away the talus of *débris*.

This structure of the basalt greatly facilitates the formation of cañons in it by erosion. No doubt a stream first finding its way through some of the fine crevices left in cooling enlarges these at the bottom, and thus produces, little by little, a wide, smooth chasm. Indeed, it is not impossible that the lost river to which I have alluded may some day, industriously undermining its roof, appear as a visible torrent at the bottom of a deep cañon.

Many of these features can be studied with great ease, and under the inspiration of glorious natural beauty at the great Shoshone Falls of the Snake. (The lecturer here sketched rapidly upon the black-board the outline of these falls and of the basaltic cliffs above and below them.) There are no large pictures of these falls at present available; otherwise I should not be so audacious as to attempt to convey an idea of their form—still less of their beauty—in so rude a manner. They are situated about twelve miles above the crossing of the Snake Cañon by the stage-road from Boise to Salt Lake They are accessible without much hardship from the Pacific Railroad, by twenty-four hours' stage-travel to the station of Rock Creek, and a ride or walk across the sage-desert of half a dozen miles. The surface of the country appears to be an unbroken, scarcely undulating plain, dotted with the gray tufts of the sage, and black, here and there, with patches of bare volcanic rock. As one approaches the cañon of the river, its presence is betrayed by the sound of its flowing, until at last one comes suddenly upon its bold brink, and sees the stream 600 feet below.

The opposite side of the cañon presents an excellent vertical section, showing both the bedded and the columnar structure of the basalt, and thin layers of sedimentary deposits between the successive overflows. The whole thickness of the basaltic formation is about 400 feet; and below it is revealed porphyry, to the further depth of 200 feet. Through both of these the cañon has been carved; but it is apparently a much slower and more difficult work for the stream to wear away by honest friction the masses of porphyry than it was to subtly undermine and overthrow the stately pillars of basalt.

The roar of the falls is heard in the distance, and a rising cloud of mist indicates their locality. Riding along the edge of the cliff for two or three miles, we come upon one of the most romantic scenes of the world. We surprise the river at its work. Its basaltic channel was long since complete, and, not satisfied with that, it is patiently sawing, foot by foot, into the porphyry. Below the falls this rock has been excavated some 200 feet in depth; and this is almost exactly the height of the falls themselves. There are almost no rapids immediately above, and none at all immediately below; the stream makes practically but one leap, in a sheet, broken at low water by projecting rocks, but majestic in times of flood as the segment of a huge, revolving wheel. Figures are perhaps as impressive as words in such a description, since they leave the imagination freer play in filling up the outlines of the scene. A cañon perhaps 1,000 feet in width, 400 feet deep above the falls, 600 feet below,* and a great river plunging from one bed to the other—this is the frame of the picture. As if unwilling to leave so grand a beginning without some delicate touches of milder beauty, nature has relaxed the sternness of her desolation, and clothed the gray ruins of the precipices with green trees and grass, nourished by the mists of the cataract. The sun, busy through all the surrounding plains in fierce destruction, here condescends to the graceful labor of scattering diamonds in the foam and painting rainbows on the mist. A little way above the falls the river divides, inclosing between its two arms a remnant of the overlying basalt, massive and castellated, like a great fortress, defying destruction; and almost on the edge of the falls, protected no doubt by this fortress farther up the stream, stands a still smaller relic of the former rocks, a pillar of basalt, upon the top of which was seen by the earliest pioneers who penetrated to this place an eagle's nest. For a score of years it has remained—how much longer no man can tell—and is still inhabited by the proud and solitary pair whose reign there is none to dispute.

Despite the forbidding appearance of the precipitous cliffs, it is possible to descend into the cañon below the falls. Numerous clefts and fissures extend through the basalt to the porphyry, and by scrambling, sliding, and dropping, aided by the stout branches of drooping trees, it is possible to reach the bottom. Many of these fissures are spanned above by natural bridges. Some of them are closed at the top, with openings here and

* The height of the cliffs below the falls is 620 feet; the height of the falls is said to be 216 feet.

there, through which we may look down into deep narrow caves, with glimpses, far below, of sunshine and the flowing river.

The view of the falls from beneath, though of course impressive and beautiful, is not the best that can be obtained. The characteristic feature of the scene, the great depth of the cañon above the upper level of the stream, is dwarfed in perspective, and the beauty of the stream just before its final plunge is hid from view by the tumbling waters themselves. The most magnificent aspect, combining in one picture nearly all the elements of power and grace, of bold outline and tender shadow, of towering height above and dizzy depth below, is obtained from a jutting point of the crags below the fall and nearly on a level with its edge. It was from such a position that Mr. Clarence King's party of explorers, suspending their photographer and his instrument in mid-air, as it were, in front of the great cataract, obtained an excellent picture of this unique scene.

I have said enough, I trust, to convince you that the far Northwest has much to show us and to tell us that will be valuable to science and to art. I hope it will not be long before its natural features will be thoroughly explored and described. Pacific Railroad parties have crossed and recrossed it, intent rather on the best way to get through its passes and across its wilderness than on the study of its character and history; the miner and the emigrant have traversed it with indifference, save where it promised fruitful farms or golden treasure; the Indian and the trapper have roamed over it, with keen but ignorant observation. But the time for all such imperfect explorations of our great interior has passed. The recent governmental survey of the belt through which the Pacific Railroad runs is a specimen of a more thorough, elaborate, and permanently valuable contribution to our knowledge of the continent. I hope it may be followed by others, as well-equipped and as well-conducted as this has been by its young but famous leader, Clarence King, with whose name those of Hague and Gardner are worthily associated. Surely the government of this great country cannot do a wiser or a nobler thing than to give to the world a faithful picture of the mighty realm beneath its sway.

Since the foregoing description was written and made public, the rediscovery of gold in the bars of the Upper Snake has led a considerable temporary population to the neighborhood of the great falls.

THE SNAKE RIVER BARS.

The bars on the Snake River have long been the resort of placer-miners at times when the lack of water caused the suspension of operations in the camps of Boise Basin and other localities, usually toward the close of the season, when the smaller streams are dry. Indeed, it is not practicable to carry on bar-mining in the Snake while the stream is high; and even under the circumstances above mentioned, it is usually expected that the bars will merely enable a few hundred men to earn "wages"—$5 to $8 per day—and so find steady employment at a time when they would otherwise be forced to remain idle. The seasons of 1869 and 1870, however, were both characterized by drought; and the unusual low stage of water early in the summer, while it impaired the productiveness of many interior camps, gave rise to increased activity along the great river. During the former year I followed the Snake cañon for some distance, visiting *en route* the celebrated Shoshone Falls; and it must be confessed that I found its precipitous basaltic walls, with their coarse *débris*, not promising for river-mining. Near these very falls, however, some discoveries of gold in the river-channel, made in the summer of 1870, created considerable excitement, and called together suddenly a temporary population, where at the time of my visit there was no sign of human habitation. From the information I have been able to gather, I am led to believe that the gold deposits of this part of the river are limited in extent and quite moderate in their yield of precious metal, while the operations of mining are difficult in the most favorable seasons, and will be quite impracticable when high water prevails. The following account of these mines, extracted and condensed from a letter addressed July 15, 1870, to the San Francisco

Bulletin, presents a clear picture, and agrees well with my impressions derived from personal observation and from conversation with others:

The discovery of gold on this river is by no means a recent thing, having occurred, along its lower portions, soon after the opening up of the mines in the Boise Basin, and farther down, about Lewiston, somewhat earlier. The extreme fineness of the particles, however, it being what is denominated "flour dust," prevented these diggings being worked at that day, the means for saving this excessively fine dust having been less perfect then than at present; a further reason for their neglect being that much better wages could then be made almost anywhere in the mines of Eastern Oregon and Idaho than here. It has been the case, however, that small parties have for several years past worked occasionally on the bars in this vicinity, as well as a few points still higher up. In the summer of 1864, a well-appointed company left Boise to prospect the Upper Snake and its tributaries; but, meeting with resistance from the Indians, they were obliged to abandon this purpose, having only ascertained that there was at least a show of gold along the streams in that region. Ever since these attempts have been annually renewed, only to end for the first two or three years in similar results, no considerable amount of work having been accomplished until last year in that quarter. Through these persistent efforts, prosecuted both from the east and the west, the main stream has been traced and examined quite to its source, in the Wind River Mountains, while the most of its upper tributaries have also been pretty effectually explored. On nearly all the bars, both on the two principal forks, as well as the confluents, gold has been found—always excessively fine and generally only in limited quantities—nowhere in very great quantities.

Owing to dearth of water, and consequent difficulty in working the mines throughout Idaho last year, a larger number of men than ever before were tempted to try their luck on this river, the most of whom located in this neighborhood, where several good bars had previously been found. Arriving at a time when the water had reached a tolerably low stage, and having the culling of the ground, the most of them made fair, and a few very large wages. Scarcely any of these men made less than $5, while quite a good many took out from $10 to $15 daily. Occasionally as much as $50 or $60 were worked out by two men with a single rocker, and it seems likely that the individual earnings of the forty or fifty men strung along this section of the river were not less than $7 or $8 per day. The Bascon claim, situate on the north side of the river, quarter of a mile below this place, yielded at the rate of $20 per day to the hand throughout the season; and two men are said to have taken out $175 in one day. This, however, occurred but once, and the claim in question is admitted to have been much the best of any in this vicinity or anywhere else along the river. The average earnings of those at work any considerable distance either above or below here are generally estimated to have been about $5 per day; the entire number of men engaged in working last fall on bars above the old diggings having been about one hundred.

The water in this river reaches its lowest point late in the autumn, at which stage it remains until about the middle of April, when it commences to rise, and, going up slowly at first, and more rapidly after two or three weeks, reaches its greatest height toward the latter part of June, when it again begins to subside, going down at the rate of two or three inches daily thereafter. While it is true, as a general thing, that the lower the water the better the diggings, it is still the case that a few of the larger and more elevated bars can be worked to best advantage when the river is high, as at present, hence a small number of men are now engaged working on these exceptional spots, their earnings running, as near as can be ascertained, from $3 to $4 per day. On two or three claims, however, they have been doing better than this, the owners paying their hands, in one case, $5, and the others $4 per day, with board. As the river recedes more men are getting to work, though it will be three or four weeks yet before any considerable number of claims can be worked to advantage. Meantime there are a goodly number of men here out of employment; and being also out of means, some of them are dependent upon their neighbors for their daily food, and there would be no difficulty in finding numbers of good hands willing to work for their board, were there any one desirous of employing them on those terms. Discouraged by this state of affairs and a shameful monopoly of the best grounds by the early comers, held under claims of unusual dimensions and pretended sales, a great many have left the mines, the arrivals on the river at this point being just now scarcely in excess of the departures from it. In fact, there is nothing to be gained in being here at present, the middle of August being about as soon as the river can be prospected and claims located to advantage. From what has been said it will be seen that the best season for work here extends from about the 1st of September to the latter part of November, during which the water is constantly receding. Early in December—though sometimes not before Christmas—the weather becomes too cold and stormy for successful operations, continuing so with short intervals till about the 1st of March, when work can be resumed and kept up without much interference from cold or high water till near the middle of May.

The seasons here are about the same as in the State of Nevada—hot and dry summers, with cold winters and deep snow on the mountains, though but little falls along the river or in the adjacent valleys. The autumn and later spring months are pleasant, with but little stormy weather. Miners can winter on the river without much hardship; and as a good deal of work can be done to advantage, it is likely that many will tarry here till spring, prolonging their sojourn till the next rise of water sends them away. Although there is no timber on or near this part of the river, enough of driftwood can usually be obtained for fuel, and at many points also for the construction of cabins, although the latter can readily be made of rocks and other convenient materials.

The river, when high, is a large stream, carrying a volume of water equal to the San Joaquin or the Sacramento. For a good part of its course it flows through rocky and precipitous cañons, its banks for fifty or sixty miles in this vicinity consisting of nearly perpendicular walls of volcanic rock. Its current, wherever it is narrow and thus walled in, is swift, being at many points hastened by falls and rapids. At Shoshone City there is a cataract 100 feet high, and four miles below another, the Great Shoshone Falls, 210 feet in height, with several violent pitches in the river immediately above them. There are no trees along this stream, except a very few cedars along the Great Falls, lower down the mountains whence it issues two hundred miles above. The country along it is also treeless—everywhere extremely barren. The bars in the cañons, where only as yet much rich dirt has been found, are generally small and narrow, and being covered for the most part with rock, will afford but comparatively little auriferous earth, while they will be difficult to work. The river water is of good quality, and though cool earlier in the season, is now growing warm, owing to the great distance it has to traverse the hot and arid plains after leaving the mountains.

Everything considered, there would seem to be as many people now on this river as prospects would warrant. At all events, there is, for the reasons stated, no hurry about getting here just yet. The miner who was unable to come in time to avail himself of the opportunities afforded by the low stage of water in the spring may as well postpone his coming for another month or six weeks yet at least, as he will then arrive at a period when he can examine the mines with satisfaction, and soon determine whether it will do to remain or not. But little can be done and not much known of the diggings by actual test earlier than that. Meantime the weather here is dry and hot, provisions rather dear, and life in every respect about as cheerless and uncomfortable as it well can be. Without lumber, there are no houses to protect one from the sun which glares fiercely down the live-long day. It is difficult to ever find enough brush to constitute a shade, the best refuge from the heat being the caves, here numerous, or the shady side of a rock.

It is a peculiarity in affairs here that—all being impressed with the idea that their stay will be short and business evanescent—no improvements of a permanent kind have been, or seem likely to be, undertaken. No houses or other buildings are put up; no roads or ditches constructed; no farming or mechanical pursuits engaged in; and, in short, no work of any kind, except mining, to be done, and just now we have seen but little of that.

Shoshone City, the largest hamlet on the river, consists of four canvas shanties and a tent, all used as trading-posts. At present, they are, with two exceptions, located on the high bluff overlooking the river, though the most of them are to be transferred, in a few days, below, nearer to the mines, a rude wagon-road having been gouged out of the cliff to facilitate the work of removal. At the mouth of Dry Creek, fifteen miles above here, there are four stores and a restaurant, which, with some half dozen miners' tents, constitute the bulk of that town. There is also a store at Clark's Ferry, twenty miles below here, there being three or four additional trading-posts scattered along this portion of the river. At these places miners' supplies of all needed kinds can be procured, and generally at fair prices; wherefore it is hardly worth while for parties coming here to encumber themselves with provisions or other luggage. Fresh beef and mutton can also be had at reasonable rates, while the river affords trout, salmon, and other inferior fish in considerable numbers.

The last statement in the above account I must take leave to doubt There are no salmon in the Snake River above the Shoshone Falls, nor, unless I am much mistaken, for a considerable distance below. I have caught trout and other fish immediately below the great fall. The absence of salmon in the Upper Snake is curiously connected with the celebrated expedition of Lewis and Clarke at the beginning of the present century. It will be remembered that these daring explorers ascended the Missouri to its sources, and Captain Lewis, crossing the divide, discovered the headwaters of the Snake River, which was called the Lewis River in honor of him for many years, (though the name of Shoshone

or Snake, bestowed upon it by the Indians, in allusion to its serpentine course, has always been more commonly used by the inhabitants, and will doubtless survive.) Following this stream for some distance, Captain Lewis satisfied himself that it contained no salmon, and that the tribes on its banks were unacquainted with that fish. From this he reasoned that the river was not part of the Columbia, the headwaters of which he was seeking, or else that large falls intervened between the portion he examined and the sea. He consequently turned back and recrossed the divide; and the party taking a more northerly pass, reached the Columbia by another route. Lewis may be said to have surmised the existence of the great American and Shoshone Falls, which he did not actually see. Subsequently Frémont crossed the Wind River Mountains, and passed down the Snake to a point which I judge must have been not far above the upper fall; but deterred by the gloomy barrenness of the country, he forsook the river and struck northward to the Clearwater. The grand basaltic cañon of the Snake has thus remained but little known in literature. Some description of it has been given in the foregoing account of the basaltic scenery of the Northwest. Doubtless mining operations on the upper part of the river, if successfully continued, of which there appears to be some doubt, will result in making the region better known both to tourists and to readers.

ALTURAS COUNTY.

The high prices of labor and materials have continued to exert upon the mining industry of this county an unfavorable influence. Wages are reported to be still as high as $5, $6, and $8 coin per day—a burden which no district could be expected to bear. The placer-mines especially, not being able to pay such wages, have fallen mainly into the hands of the Chinese. Rocky Bar, one of the most noted camps of the county, has suffered somewhat from the stampede to the bars of the Snake River; but has maintained, notwithstanding, a considerable production. The Idaho mine, now owned by Messrs. D. F. Settle & Co., is reported to have produced $20,000 during the summer. Small lots of the ore, amounting to twenty or thirty tons, are said to have yielded $200 per ton in mill.

Red Warrior district has been comparatively quiet. The Casco Company, owning the Wide West, (see my last report, page 248,) was idle during the summer, but was expected to resume work in the fall.

The Monarch Company, in *Yuba district*, was running for six months during the year ending June 1, 1870, and produced $50,000. The Atlanta lode, owned by this company, was described in my last report. It is reported to have been sold in London to an English company; and the appearance of a prospectus in the English papers confirms the report.

According to a correspondent of the Boise City Statesman, the scene of the most active development in the county during the summer was Bonaparte Hill, situated some seven miles in a southeasterly direction from Rocky Bar. The Bonaparte Company and the New York and Ohio Company are both working on this hill, and, it is believed, on the same lode. Four or five hundred tons of ore had been extracted by the middle of August, and were awaiting the completion of a mill. The expected yield was between $75 and $150 per ton. The wages paid here were $2 50 to $3 per day, currency, "and found," for miners, and $6 per day for mechanics.

IDAHO COUNTY AND NORTHERN IDAHO.

The quartz mines of Warren's camp appear to have made but little progress toward steady production, though there has been considerable activity in prospecting. My correspondent, Mr. Richard Hurley, an assayer of long experience, and a gentleman well acquainted with the mines of Northern Idaho and the Upper Columbia, writes concerning this camp under date of February 4, 1871: "All that I have to say at present is that the quartz mines which are now worked are paying well, averaging some $50 to the ton in gold, and the silver ledges averaging about $85 to the ton. They did not commence working till last October, so I cannot give much detailed information concerning them. I have assayed since that time about $10,000 from quartz, mostly obtained by prospecting merely on the different ledges. The prospects at this camp are very flattering."

For the year ending June 1, 1870, Mr. Hurley reported the sum assayed at $2,500. The average yield of the placer-claims reported from Idaho County was $5 90 per day per hand, wages being about $2 25. Washington district contains a number of claims which produced in the neighborhood of $10,000 each during the season of four or five months. In Florence district, the yield of single claims seems not to have exceeded $6,000.

My correspondent at Lewiston reports the yield of the northern camps to have been about the same as usual. Shoshone County still maintains a considerable production in hydraulic as well as placer mining. The average yield of twelve hydraulic claims reported was $6 to $10 per day per hand, the average wages being $50 per month. Mr. W. Shepherd, and Messrs. Campbell, Black & Co. have the largest claims, each producing over $10,000. The average yield from eighty-eight placer-claims was $2 80 per day per hand. Most of these claims were worked by owners, paying no wages. The average yield of a few claims paying wages at the rate of $40 per month was $6 63 per day per hand. The total product of the eighty-eight claims was a little over $300,000; but this constitutes only a portion of the actual yield of the county.

LOON CREEK.

At the Loon Creek placer-mines, situated about one hundred and twenty-five miles northeast of Idaho City, (see my last report, page 251,) about two hundred men have been at work. The extent of the diggings is about four miles along the creek. Being so near the mountain snows, this stream is subject to freshets and high water, which delay the commencement of the working season till about the 1st of July, except in dry years. Hence the production of such camps begins after work in the basin has well nigh ceased. The gold of Loon Creek is reported to be of fine quality, worth $17 per ounce.

CHAPTER V.

MONTANA.

I had intended to visit this Territory personally during last summer, but the unavoidable delay in the public printing office in the publication of my last report detained me at the East until late in the fall, when cold weather had already set in in Montana. The present chapter contains such imperfect statistics as I have gathered from correspondents and other reliable sources during last year.

It is a notable fact that many of the placer and hydraulic claims have not been enabled to keep up operations for more than a few months, the excessive drought which existed on the Pacific coast having extended into Montana. Still a large number of them have yielded excellently, and higher than the majority of the mines of this class in other States and Territories. The quartz mines, it appears, have not done as well as in former years, less of them being in actual operation. But the influence of reduced freight, owing to the Union Pacific Railroad, is beginning to be felt, and preparations which will materially increase the product of Montana are in progress. It is also notable that less speculation, and comparatively more *bona fide* mining, is the order of the day; and the enterprises of the latter class progress cautiously, and in a manner which shows that the present miners have largely profited from the experience of the past.

I estimate the product of Montana for 1870 at $9,100,000, as follows:

Shipped overland per express	$4,800,000
Overland, in private hands	2,000,000
Via Fort Benton and River	800,000
Via Walla-Walla	1,500,000
	9,100,000

Although the governor of the Territory, in a recent letter, (February 17, 1871,) has given the bullion product as $12,000,000, I am still inclined to consider the above estimate more correct, though it may be somewhat lower than the facts will warrant. The exact sum is more difficult to ascertain than the product of any other Territory. The very high rate charged by the express company for the transportation of bullion, and the fact that most of the product is gold dust, lead to a heavy undervaluation of bullion by shippers, (from 25 to 30 per cent.,) and an extraordinary amount of transportation in private hands. The latter item is estimated by the express agents at half the product of the Territory. The invoiced amount shipped by express via Ogden and Corinne during the year was $3,937,720, representing an actual shipment of at least $4,800,000. The lowest estimates I have received in regard to the other routes justify me in crediting them with the amounts above named. As the cost of freight from the railroad on 18,000,000 pounds of supplies hauled during the year amounted to $2,700,000, and the wages paid to miners in the Territory continued to be very high, it is difficult to conceive how the product of the industry of the mining population could have been less than the estimate here given.

DEER LODGE COUNTY.

The gold product of this county during 1870 is estimated by the New Northwest, a well-known local paper, at $4,000,000. Though this estimate is possibly slightly exaggerated, it cannot be very far from the real product. Placer-mining and hydraulic mining have both been very successful, though actively carried on only a part of the year. To the two hundred and eighty miles of ditches, carrying 20,000 inches of water, many more have been added; and some of the new ditches, as the Upper and Lower Race track, Cable and Butte, will, when completed, open up extensive and rich new mines.

The census reports, giving data for the year ending June 1, 1870, enumerate one hundred and ninety-five placer-claims, but this number does not cover nearly all of them. In these claims, however, nine hundred and ninety men found employment during an average of about four months, receiving average wages of $115 per month. The placers reported are located in Washington and Lincoln Gulches; Silver Bow, Butte, Rocker, Jefferson, Blackfoot, Beartown, Bear, Elk, and Deep Gulches; French and German Gulches; Henderson, Cariboo, Modesty, and Dry Gulches. The total yield of all these claims is reported at $1,170,865, and the average yield per day per hand was $12 09. The more prominent claims, as far as the product is concerned, are the following:

Lincoln Flat Company, Lincoln Gulch, twenty men employed six months	$34,000
Discovery Company, Lincoln Gulch, five men employed	12,000
Wilson & Bro., Lincoln Gulch, four men employed six months	15,000
Patterson & Co., Lincoln Gulch, nine men employed six months	20,000
Kelley & Co., Lincoln Gulch, six men employed two months	10,000
Horten & Co., Lincoln Gulch, six men employed six and a half months	24,000
Egleson & Co., Lincoln Gulch, ten men employed six months	50,000
Brunskell & Co., Lincoln Gulch, six men employed five months	11,600
Keys & Co., Jefferson Gulch, three men employed four months	10,000
Haines(?) & Bro., Jefferson Gulch, seven men employed six months	13,500
Maxey & Co., Blackfoot, five men employed five months	10,000
Montgomery & Co., Blackfoot, twelve men employed six months	10,000
Williams & Co., Blackfoot, four men employed four months	12,000
Fenner & Co., Beartown, ten men employed twelve months	50,000
Horan & Co., Beartown, eight men employed twelve months	37,000
Gibbs & Co., twelve men employed five months	30,000
McGhee & Co., fifteen men employed thirteen months	55,000
Smith & Co., five men employed seven months	10,000
Hiland & Co., five men employed eight months	11,250
Wurger & Co.,* six men employed eight months	12,000
Morse & Co.,* fourteen men employed five months	20,000
Mosby & Co.,* six men employed six months	18,000
Shams & Co., French Gulch, fifteen men employed one month	10,000
McLame & Co., Blackfoot, five men employed six months	12,000
Prior Company, Blackfoot, twelve men employed eight months	30,000
Bealton Company, Blackfoot, nine men employed six months	12,000

* These claims are reported as in Bear, Elk, and Deep Gulches. Which gulch contains each claim I cannot say.—R. W. R.

Beal & Harris, German Gulch, fifteen men employed one and a half months	$12,000
Gardner & Stone, German Gulch, twelve men employed two months	10,000
McCling & Co., German Gulch, twelve men employed two months	10,000
Funel & Co., Henderson Gulch, five men employed six months	12,000
Butler & Co., Henderson Gulch, five men employed six months	18,000
Ferguson & Co., Henderson Gulch, six men employed seven months	12,000
Sullivan & Co., Modesty and Dry Gulch, three men employed eight months	11,000

Of hydraulic claims, twenty-six are reported, employing two hundred and fifty men during six months on an average, and at average wages of $130 per month. The total product of these is given at $530,000, which shows an average of $13 47 per day per hand. The following claims gave the highest yields:

Roberts, Fly & Co., employing six men five months	$10,000
Blau & Co., employing fifteen men eight months	50,000
Holcomb & Co., employing fifteen men eight months	70,000
Kitching & Co., employing twenty-three men six months	100,000
Smith & Co., employing eight men five months	15,000
Pioneer Company, employing fifteen men six months	45,000
Enterprise Company, employing twelve men three months	14,000
Dutch Company, employing two men six months	18,000
Hagan Company, employing eight men eight months	20,000
Walker & Co., employing seven men eight months	15,000
McLean & Co., employing seven men six months	12,000
Scott & Co., employing nine men six months	12,000
Chang-Ling Company, employing seven men six months	13,000
Ah Ran & Co., employing eight men six months	12,500
Ah Yank & Co., employing seven men six months	9,000
Nason & Co., employing six men six months	12,000
O'Niel & Co., employing seven men six months	10,000
McDonald & Co., employing eight men six months	15,000
McDougal & Co., employing seven men six months	12,500
Irvin & Co., employing thirty men six months	25,000

Of over fifteen hundred quartz lodes recorded in the county very few have been in successful operation. The census reports only six claims, employing sixty-six men during an average of 3.1 months. Of these the St. Louis and Montana Mining Company ran their mill during one and a half months, and produced a little over $7,000; the Only Chance worked eight arrastras during five months, and produced 1,700 ounces of gold, worth $37,000; and the Highland Gold Company at Blackfoot produced $2,645. All these statements refer to the year ending June 1, 1870. Later in the year the Stuart Mill (belonging to the St. Louis Company) was reported as doing a successful business under the management of Captain George Plaisted. Twelve tons per day were crushed at the time with satisfactory results.

The Cable lode (probably the Atlantic Cable) is reported in active operation again. Mention of this magnificent lode was made in my last report. The former wasteful mode of mining seems to have given way to systematic working. In July Mr. Cameron, the superintendent, employed some fifty men about the mill and mine. But two clean-ups had

been made since the hoisting works were put in operation; but the amount of ore in sight warranted the belief that there is no cause to apprehend that the mill would again be compelled to lie idle for the want of quartz. The company continued work in the mine regularly, and in September work was being carried on day and night. The company was sinking the main shaft, opening up lower levels and taking out quartz. The main shaft was then down 150 feet. Ninety-three feet from the surface a tunnel leaves the main shaft for the upper level, a distance of 400 feet. The ledge at the thickest part is over 50 feet, and by far the most of the ore pays well. The rock is nearly all stoped out in the upper level. The mill was expected to run regularly before the 1st of October. The main shaft is intended to be sunk until it intersects the ledge, when large quantities of quartz will be ready to be taken out. A good engine for hoisting and pumping is on the ground, and works splendidly.

The Miners and Mechanics' Tunnel, near the vein just mentioned, was also actively prosecuted, and since the middle of the summer the rock has been much softer than formerly, so that quicker progress could be made. It was expected in August that the ledge would be struck soon, but I have not had any information in regard to it since then. The company, which is a coöperative one, the shareholders being working-men, deserves ample success for its persevering energy. They have carried on their work steadily for nearly three years without aid from others.

A number of other mines are mentioned by my informants as giving good results during the year, but I am not informed as to the continuity of their operations. Among these the silver mine of Mr. H. Beck, on the Big Hole River, the mine of Day & Harvey, and the Dixie lode, belonging to Parker & Dickey, seem to be very promising. The last is a gold lode, carrying free gold in quartz, which is reported to be worth $45 per ton. The ore is worked in an arrastra. The Trout mine, belonging to the Cole Saunders Gold and Silver Mining Company, is a valuable lode, and the late vicissitudes of the company seem to have been effectually settled at last. The Independent published in the fall the following in regard to this mine:

The "Trout" is a seven-foot lode, crossing the strata of limestone country rock at right angles. It is developed on the surface a distance of 1,000 feet. The upper level, 50 feet below the surface, and in 45 feet from the main shaft, shows a 7½-foot lode, and a richer quality of rock than upon the surface. The lower level, 85 feet from the surface, shows a still better quality of rock. There are some three hundred tons of ore on the dump, roasted and ready for the furnace. The smelters consist of three furnaces and a cupeling furnace, with steam-power. The trouble hitherto has been the want of galena for fluxing. A small supply was lately procured, and satisfactory tests have been made with a small furnace of 1 foot interior diameter, and 9 feet from the tuyéres to discharge-hole. The furnace is now running finely, and yielding about one-half ton of metal (worth $700 per ton) every twenty-four hours. On September 10 the employés of the mine, members of the company, creditors, &c., met at the office of the company for the purpose of agreeing upon the conditions of a settlement. After fully discussing the conditions of the proposed settlement, a lease containing substantially the following conditions was agreed upon: The Cole Saunders Silver Concentrating Company lease to Henry Schnepel, as agent of the employés, two of the furnaces and the 50-foot level of the Trout mine, together with all the ore on the dump, said Schnepel to furnish two hundred tons of galena for fluxing, and all supplies until the employés are paid off. Said lease to remain in force until the objects named are accomplished. The Cole Saunders Company retain their lower level and the main shaft, which will be kept running vigorously. They also retain one furnace for their own use and benefit. Matters are thus now placed on a permanent basis for regular operations. The capital furnished by Mr. Schnepel will relieve Cole Saunders of his financial embarrassments, and enable him to continue running the one furnace steadily on the company's account. Cole Saunders, in building and perfecting these works, has accomplished wonders, considering the obstacles against which he had to contend. Mr. Schnepel, the lessee of the

mine and works, is one of the solid men of Deer Lodge County. He is a careful business-man, having gone into this enterprise after analyzing the ores and bullion, and counting the cost, and this gives further assurance of the entire success of the works.

In both quartz and placer mining many new and important enterprises are in the course of realization. The one promising the greatest results is probably the new ditch, which will undoubtedly be constructed in order to supply the mines of Gold Creek with a more abundant supply of water. It is proposed to take the water from the Deer Lodge River, near the mouth of Warm Spring Creek, and convey the same along the foot-hills to the bars at and near Pike's Peak. This is the only source from which an abundant supply of water can be obtained to successfully work these mines. The ditch probably would cost $150,000, but there is no doubt that it would be a profitable investment. There are large areas in the Gold Creek country that prospect well, but they cannot be developed for want of water until the mines now opened there are exhausted, which good judges think will not be at an earlier period than ten years, and some even claim that it will take double that time. Some good prospects have been obtained near the line of the proposed ditch, not very far from Pike's Peak. There is no doubt there is much good mining ground all along the foot-hill, from a point due west of Deer Lodge City to Gold Creek, and perhaps beyond that point. There is much of the table or bench lands in this valley that would make excellent farms if water for irrigation purposes could be obtained. This ditch could be made sufficiently large to carry enough water for agricultural and mining purposes. The greater portion of the way of its course would be over a splendid country for ditching, and the remaining distance is what might be termed fair ditching ground. The length of the ditch would be in the neighborhood of forty miles, the first twenty of which could nearly all be plowed and scraped, thus materially lessening the cost of construction.

LEWIS AND CLARKE COUNTY.

Both quartz and placer mining were actively prosecuted during part of the year. The former was carried on with more than usual energy in the latter part of the summer and fall.

The census reports give for the year ending June 1, 1870, sixty-one placer-claims, which are nearly all located in the southern part of the county. These mines employed five hundred and eighty-two men, on an average of 3.5 months, at wages of about $100 per month. The total product during the time mentioned was $428,643. This denotes an average per hand per day of $8 76. The following claims have given the most prominent yields:

Currier, Foot & Co., employing four men seven months	$9,500
Nash & Murphy, employing two men seven months	10,000
Morey & Co., employing six men seven months	15,000
Quick, Stanton & Co., employing two men eight months	12,000
Brown, Bell & Co., employing six men twelve months	20,000
Collins & Co., employing three men twelve months	21,000
Crary & Co., employing eight men six months	10,000
A. Williams, employing forty-two men two months	12,000
Hurt, Chesmar & Co., employing forty-five men	41,615

Of quartz establishments, according to the same authority, there were six in operation in the same year during an average of 7.3 months. They furnished employment for one hundred and ninety-six men, who

received average wages of $75 per month. The total yield of the mines of these companies was $219,325, the ore being crushed in the following mills and yielding the subjoined amounts:

Park Mill, employing forty men during eight months	$15,800
National Mining and Exploring Company's mill, employing forty-five men during four months	85,000
Ricker's Mill, employing seventy men during nine months	68,400
Plymouth Gold and Silver Mining Company's mill, employing ten men during three months	6,000
Diamond City Mining and Milling Company's mill, employing six men during six months	14,125
Charles Hendrie Mill, employing twenty-five men during ten months	30,000

All these mills, with the exception of the Park Mill, are mentioned in my last report, page 290. Their capacity, etc., can be found in that place.

In the fall the quartz-mining enterprises, many of which had been going on in a somewhat irregular way during the summer, took a new start, and in October all the mines on the famous Whitlatch Union lode were reported working and all the mills in the neighborhood running with satisfactory results.

MEAGHER COUNTY.

This county was described at length in my last report. There were at that time no important quartz-mining enterprises in the county, and I am not informed that any have been started and brought to a paying basis during the last year.

In the census reports only placer and hydraulic mines are enumerated, nd these classes of mines are the only ones of which I have any knowledge in the county.

Of hydraulic mines the census reports contain the returns of twelve claims, which employed sixty-five men during an average of 4.25 months, at average wages of $86 50 per month. The total yield was $59,044, and the average per day per hand $8 15. All these claims are located in New York Gulch, Diamond City, and vicinity. They have mostly produced less than $9,000 during the year ending June 1, 1870.

The placer mines reported are also all located in New York Gulch and Diamond City. Of these ninety-three have employed three hundred and fifty men during an average of 6.2 months, at average wages of $72 per month. The total yield was $407,576, and the average yield per hand per day $7 21.

The following claims gave the highest yields:

J. R. Weston & Co., New York Gulch, employing thirty men six months	$25,000
A. S. Warren & Co., New York Gulch, employing fifteen men six months	19,800
W. C. Dawes & Co., New York Gulch, employing eight men eight months	18,000
Buckingham & Co., New York Gulch, employing eight men five months	15,000
Rosenbaum & Co., New York Gulch, employing five men seven months	12,240
William Casper, New York Gulch, employing four men seven months	9,360

Morgan & Co., New York Gulch, employing four men three months	$12,078
Woodward & Co., New York Gulch, employing five men twelve months	13,068
Brennan, Steel & Co., New York Gulch, employing four men twelve months	9,360
J. Shields & Co., Diamond City, employing four men ten months	9,909

The copper mines east of the Belt Range have not been worked during the year, so far as I am informed, nor are they likely to attract much attention until the cost of transportation is considerably lessened.

JEFFERSON COUNTY.

Considerable excitement has prevailed in this county in the latter part of the summer and in the fall on account of the discovery of several rich gold veins in the neighborhood of Radersburg.

The placer-mines also appear to have given satisfactory returns during the comparatively short time they were in active operation.

The census reports one hundred and thirty-six claims from Spring Bar, Peru, Old Bar, Overland, Rocker, Hunter Jack, Basin, Crow Creek, Wilson, Holmes, Ruckley, Mitchel, and Hogan. Although many of the older claims of this county are worked out, yields of $17, $20, and even $25 per hand per day have not been unfrequent. One hundred and twenty of the one hundred and thirty-six claims reported by the census employed three hundred and five men during an average of 4.5 months, at average wages of $100 per month. The total yield was $228,115, and the average yield per day per hand, for all of them, $6 33. The average yield of the claims paying hired help an amount exceeding $1,000 was $7 37 per hand per day. Most of the claims have, however, produced small amounts in the aggregate, and the following few are the most prominent ones:

Boulder & Co., Spring Bar, employing six men six months	$7,000
Favert, Day & Co., Basin, employing sixteen men three months	7,000
Wm. Quinn, Crow Creek, employing five men three months	9,000
T. H. Randall, employing five men eight months	10,000
J. H. Halford, Basin, (hydraulic mine,) employing ten men four months	10,000

Of the quartz mines the census reports a total product of only $16,632 for the year ending June 1, 1870, and nine mills and arrastras in operation during a very small portion of the year.

The Ironclad, Keeting, Diamond, and Leviathan appear to be the most prominent lodes at present. On the first J. F. Allen has a claim of 200 feet, which is opened by a shaft 90 feet in depth and by a small tunnel. The ore tested yielded $25 per ton. Nave & Co. have 600 feet, opened by a shaft 50 feet deep and a tunnel 200 feet long. Thomas Dunn has 500 feet, opened by a shaft 50 feet deep. He worked in the summer from five to eight men.

Ore tested from the Robert Lee by Thomas Allen yielded $22 per ton.

Blacker and Keeting have 2,200 feet on the Keeting lode, which they opened by a shaft 100 feet deep and a tunnel 200 feet long. The ore tests $30 per ton. They own also 1,800 feet on the Leviathan, the ore of which tested $30, and 1,400 feet on the Ohio, the ore being worth $26 per ton. These gentlemen worked their ore formerly in arrastras and a small mill, but have erected during the year a new fifteen-stamp mill,

which was in operation since the 15th of June. A week's clean-up was reported to be usually from $2,000 to $3,000 in bullion.

G. W. Brooks owns 525 feet on the Diamond lode, the ore of which yields $25 per ton.

Nave & Co. and George H. Sample seem also to have erected mills during the year, but I have no further information in regard to them.

The prospects for both placer and quartz mining are represented as encouraging for the next year.

MADISON COUNTY.

The yield of the placer and hydraulic mines of this county has not been large, though both classes have been worked longer than in any other county. But it must be borne in mind that the localities in which placer-mining has been carried on are few, and that some of these have been continually worked since 1863, and yielded fabulous amounts in former years.

Quartz-mining is permanently established in at least one district, Silver Star, where such lodes as the Everett, Green Campbell, and the Iron Rod have continued to yield handsomely, the first throughout the year.

The census returns report only nine placer-claims in operation during the year ending June 1, 1870. These employed fifty-two men during an average of 6.7 months, at wages varying from $80 to $100 per month. The total yield was $40,366, and the average per hand per day $4 42. The following claims return the largest yield:

Donegan & Co., employing ten men six months	$9,000
D. J. Emery & Co., employing seven men eight months	7,000
Knight, Noteman & Co., employing twenty-five men six months	9,000

Of hydraulic mines fifteen are reported by the census. They employed eighty-six men during an average of six months, and the average wages are given at about $125 per month. The total yield was $117,800, and the average per hand per day $8 76.

Of the more important claims I mention the following:

Stranig Mining Company, employing five men during six months	$10,000
Southmayde & Hall, employing twelve men during five months	20,000
Summit Flume Company, employing three men during five months	10,000
Pine Grove Company, employing eight men during six months	10,000
Williams, Parker & Co., employing ten men during six months	16,000
Cork Mining Company, employing eight men during six months	13,300
Donegan, McGovern & Co., employing six men during six months	12,500

Fifteen reduction works, beneficiating gold quartz, are reported. They employed one hundred and twenty-one men, during an average of 5.5 months, at $125 per month. The total product is given as $177,350 for the year ending June 1, 1870. The most important, economically, are:

The Montana Midas Company, located in Hot Spring district, which employed thirty men during three months, and took out $10,000; the Everett, Green Campbell Company, of Silver Star district, which employed twenty men throughout the year, and took out $96,000, (this company expended $45,000 in wages and $2,370 in materials;) the Ste

vens and Trivitt Mill, in the same district, which crushes ore from the Iron Rod, and employed twenty five men during six months, paying $17,000 for wages and $3,950 for materials, taking out $25,000; and Wyant Sumner's and Everson & Holman's arrastras, the former employing four men during seven months, and producing $14,000, the latter an equal number of men during the same length of time, and producing $12,000.

The business of the Everett, Green Campbell Company has been superintended by Mr. Charles D. Everett, of Cleveland, Ohio, who is one of the principal shareholders, and to whose prudent and efficient management much of the success of the company is due. This gentleman left Montana in the winter of 1870, and it is to be hoped that the business of the company may not suffer from this cause, especially as the Everett, Green Campbell is in reality the only quartz-mining enterprise in Madison County about the full success of which there is no more doubt.

BEAVER HEAD COUNTY.

The census returns for the year ending June 1, 1870, report twenty-three claims active in this county during nine months on an average. All of these are located at Bannack and vicinity. Their total product is given as $281,424, and the following claims are the most prominent:

Bannack Ditch Company	$41,184
Cañon Ditch Company	22,000
Pioneer Ditch Company	22,000
Ingram Bar	13,200
Van Winkle	13,200
Clark Bar	17,600
American Bar	15,400
Pat White's Ditch	22,000
Drain Ditch Company	19,800
Irving & Co	19,800
White's Ditch Company	13,200

There are only two mills beneficiating gold quartz, and one smelting works, smelting argentiferous galena and silver ores, reported in operation by the census. The two mills employed eighteen men during nine months, and the wages reported are only $50 per month, which is probably a mistake. The N. E. Wood Mill, which is constructed according to the plan of S. W. Bullock, of New York, and described in my last report, employed, according to the census, nine men during nine months, and produced $88,000. R. Hopkins's mill is also mentioned in last year's report. It employed nine men during nine months, and produced $41,800, according to the authority mentioned.

The Tootle furnace is the only one of the many erected in the Argenta district which has been running, as far as I am informed, but I am unable to give its product. It was in operation, however, during the greater part of the year.

Some new districts have been discovered in this county, but have as yet remained undeveloped. Vipond district is one of these. It is claimed that a section of country twenty miles long and eight miles wide is covered with float quartz, some of which is reported very rich. An occasional boulder is found of immense size, containing rich ore. Several new discoveries have been made lately that are thought to be of great importance. One of them, called the "Brick," has an eight inch crevice filled with solid quartz of good quality. Messrs. Beck

Patten, Mansfield, Spurr, and others, will sink upon their leads during the winter, and doubtless by next summer the value of the district will be determined. There is no question as to the richness of the rock, but as yet sufficient developments have not been made to fully determine the character of the veins.

MISSOULA AND GALLATIN COUNTIES.

From these two counties I have received very little information.

From the former the census returns show seventy-six placer-claims in operation during an average of 2.2 months. They employed three hundred and seventy-eight men, at wages averaging $70 per month. The total product was $88,765, and the yield per hand per day $4 16. All these claims are located on Cedar Creek, which is, if I am informed correctly, the locality on account of which considerable excitement and a partial stampede was raised in the early spring. This may also account for the very short time during which the placers were worked. Most of the claims reported by the census yielded less than $1,000, and only two have produced much larger amounts. These are the following:

Mansinger & Co., claim 400 feet front, employed twelve men two months	$9,000
Barnett & Co., claim 800 feet front, employed fourteen men three months	10,000

There were also discovered, later in the year, new mines on Big Rock Creek, a few miles west of the Deer-Lodge county-line and about fifty miles nearly due southwest from Deer Lodge City. In September news reached me that these mines were paying well. Messrs. Carpenter, Pickett & Cogswell had completed a ditch three and one-half miles long, and they were reported to have taken out as much as $25 to the hand per day. The gold obtained was very fine, being worth $21 50, currency, per ounce.

I have no information in regard to any mining which may have been carried on in Gallatin County during the year, and am inclined to believe that no results of any importance have been reached. It was in this county, in the town of Bozeman, that Henry P. Comstock, to whom is generally accorded the credit of the discovery of the Comstock lode in Nevada, (though his claim has been often disputed,) found his death by his own hands, while accompanying the Big Horn expedition.

The valley of the Upper Yellowstone, which has so long excited general curiosity on account of the wonderful reports coming from that region, has been explored in August and September by an expedition, of which Mr. H. D. Washburne, the surveyor general of Montana, was a member. This gentleman published in the Helena Herald the following account of the expedition:

The Yellowstone expedition left Fort Ellis on the 22d of August, through the Bozeman Pass, finding it all that the Bozemanites claim for it—easy and practicable—and camped for the first night on Trail Creek, having a fine view of the mountains beyond the Yellowstone. The next day they struck the valley, and their journey up the river commenced. They camped for the night at the ranch of Mr. Bottler, the last settler up the river. Crow Indians were quite plenty during the day, and a heavy rain at night gave anything but a pleasing aspect to the commencement of the trip; but a bright sun, about 10 o'clock, made everything right, and we moved to the cañon of the river, about fourteen miles distant, and camped on one of the loveliest spots in Montana. Two small streams put in from the east from an elevation near camp. The river and valley can be seen stretching away far to the north, the river-bank plainly defined by the trees skirting its margin. South the river can be seen pouring through the cañon,

while far away to the east and west the mountain peaks were then covered with snow, the setting sun brightening both in its last rays before night's mantle was thrown over the party.

We passed through the cañon next morning, and found it about six miles long, the trail leading us along the side of the torrent, and sometimes hundreds of feet above it. Night found us at the mouth of Gardiner River, a fine mountain stream coming from the south, and entering the Yellowstone just below the Grand Cañon, over thirty miles in length and nearly equally divided by the East Fork. The cañon proving impracticable, we took to the mountains, camping one night in them, and the next night a few miles above. The river runs for sixteen miles in nearly a due west course here. Our camp was on a fine stream coming in from the opposite side of the East Fork, and designated by us as Tower Creek. The camp was called Camp Comfort. Game and trout were abundant. We found here our first hot springs, small but attractive, and of five or six different kinds—sulphur, iron, &c. This cañon of the river is grand. Basaltic columns of enormous size are quite numerous. But the great attraction here was the falls on the creek, near our camp. The stream is about as large as the Prickly Pear, and for a mile rushes down with fearful velocity. It seems at some time to have been checked by a mountain range, through which it has torn its way, not entirely removing the barrier, but tearing through, leaving portions still standing; and these, by the elements, have been forced into sharp pinnacles. Looking from the cañon below, it appears like some old castle with its turrets dismantled but still standing. From between two of these turrets the stream makes its final leap of 110 measured feet, and then, as if satisfied with itself, flows peacefully into the Yellowstone. We attempted to compare it with the famous Minnehaha, but those who had seen both said there was no comparison. It was not as terrible in its sublimity as Niagara, but beautiful and glorious. You felt none of the shrinking back so common at the great fall, but rather as you stood below and gazed upon its waters broken into white spray, you felt as though you wanted to dash into it and catch it as it fell. By a vote of the majority of the party this fall was called Tower Fall.

The cañon of the main river here runs in a southwest direction. The party crossed over a high range of mountains and in two days reached the Great Falls. In crossing the range, from an elevated peak a very fine view was had. The country before us was a vast basin. Far away in the distance, but plainly seen, was the Yellowstone Lake; around the basin the jagged peaks of the Wind River, Big Horn, and Lower Yellowstone ranges of mountains; while just ever the lake could be seen the tops of the Tetons. Our course lay over the mountains and through dense timber. Camping for the night eight or ten miles from the falls, we visited some hot springs that, in any other country, would be a great curiosity, boiling up two or three feet, giving off immense volumes of steam, while their sides were incrusted with sulphur. It needed but a little stretch of imagination on the part of one of the party to christen them "Hell-broth Springs." Our next camp was near the Great Falls, upon a small stream running into the main river between the upper and lower falls. This stream has torn its way through a mountain range, making a fearful chasm through lava rock, leaving it in every conceivable shape. This gorge was christened the "Devil's Den." Below this is a beautiful cascade, the first fall of which is 5 feet, the second 20 feet, and the final leap 84 feet. From its exceedingly clear and sparkling beauty it was named "Crystal Cascade."

Crossing above the upper falls of the Yellowstone, you find the river one hundred yards in width, flowing peacefully and quiet. A little lower down it becomes a frightful torrent, pouring through a narrow gorge over loose boulders and fixed rocks, leaping from ledge to ledge, until, narrowed by the mountains and confined to a space of about 80 feet, it takes a sudden leap, breaking into white spray in its descent, 115 feet. Two hundred yards below, the river again resumes its peaceful career. The pool below the falls is a beautiful green, capped with white. On the right-hand side a clump of pines grows just above the falls, and the grand amphitheater, worn by the maddened waters on the same side, is covered with a dense growth of the same. The left side is steep and craggy. Towering above the falls, half-way down and upon a level with the water, is a projecting crag, from which the falls can be seen in all their glory. No perceptible change can be seen in the volume of water here from what it was where we first struck the river. At the head of the rapids are four apparently enormous boulders, standing as sentinels in the middle of the stream. Pines are growing upon two of them. From the upper fall to the lower there is no difficulty in reaching the bottom of the cañon. The lower falls are about half a mile below the upper, where the mountains again, as if striving for the mastery, close in on either side, and are not more than 70 feet apart. And here the waters are thrown over a perpendicular fall of 350 feet. The cañon below is steep and rocky, and volcanic in its formation. The water, just before it breaks into spray, has a beautiful green tint, as has also the water in the cañon below. Just below, on the left-hand side, is a ledge of rock, from which the falls and the cañon may be seen. The mingling of green water and white spray with the rainbow tints is beautiful beyond description.

The cañon is a fearful chasm, at the lower falls a thousand feet deep, and growing

deeper as it passes on, until nearly double that depth. Jutting over the cañon is a rock 200 feet high, on the top of which is an eagle's nest, which covers the whole top. Messrs. Hauser, Stickney, and Lieutenant Doane succeeded in reaching the bottom, but it was a dangerous journey. Two and a half miles below the falls, on the right, a little rivulet, as if to show its temerity, dashes from the top of the cañon, and is broken into a million fragments in its daring attempt.

After spending one day at the falls we moved up the river. Above the falls there is but little current, comparatively, for several miles, and the country opens into a wide, open, treeless plain. About eight miles from the falls, and in this plain, we found three hills, or rather mountains, thrown up by volcanic agency, and consisting of scoria and a large admixture of brimstone. These hills are several hundred feet high, and evidently are now resting over what was once the crater of a volcano. A third of the way up on the side of one of these hills is a large sulphuric spring, 20 feet by 12, filled with boiling water, and this water is thrown up from 3 to 5 feet. The basin of this spring is pure solid brimstone, as clear and bright as any brimstone of commerce. Quite a stream flows from the spring, and sulphur is found incrusting nearly everything. Near the base of the hills is a place containing about half an acre, but covered with springs of nearly every description—yellow, green, blue, and pink. Flowing from the base of the hill is a very strong spring of alum-water; not only alum in solution, but crystalized. This place we called Crater Hill, and as we passed over, the dull sound coming from our horses' feet as they struck proved to us that it was not far through the crust. All over the hill were small fissures, giving out sulphurous vapors. The amount of brimstone in these hills is beyond belief.

Passing over the plain, we camped on the river-bank, near a series of mud-springs. Three of the largest were about 10 feet over the top, and had built up 10 or 12 feet high. In the bottom of the crater thus formed thick mud was boiling and bubbling, sputtering and splashing, as we have often seen in a pot of hasty-pudding when nearly cooked. Near these we found a cave under the side of the mountain, from which was running a stream of clear but very hot water. At regular intervals the steam was puffing out. For some time we had been hearing a noise as of distant artillery, and soon we found the cause. Some distance above the level of the river we found the crater of a mud-volcano, 40 feet over at its mouth. It grew smaller until at the depth of 30 feet, when it again enlarged. At intervals a volume of mud and steam was thrown up with tremendous power and noise. It was impossible to stand near, and one of the party, Mr. Hedges, paid for his temerity in venturing too close by being thrown backward down the hill. A short time before our visit mud had been thrown two or three hundred feet high, as shown by the trees in the vicinity. Not far from this we found our first geyser. When discovered it was throwing water 30 or 40 feet high. The crater was funnel-shaped, and 75 by 35 feet at its mouth. We stayed and watched it one day. Without warning it suddenly ceased to spout, and the water commenced sinking until it had gone down 30 feet or more. It then gradually commenced rising again, and three times during the day threw up water 30 or 40 feet.

The next day we recrossed the river and succeeded in reaching the lake, and camped on the lower end. The fishing, which had been good all the way up the river, proved remarkably so in the lake. Trout from two to four pounds were to be had for the taking. Flies proved useless, as the fish had not been educated up to that point. Remaining over Sunday, we took up the line of march around the south side of the lake, which took us through a dense growth of pine, filled with fallen timber. The third day's march was over a mountain, and but little progress was made, the train going into camp about 2 o'clock. Mr. Everts failed to come into camp, but this occasioned no uneasiness, as we had all expected to reach the lake and believed he had pushed on to the lake, as he had once before done, and was awaiting our arrival. Moving on five miles, we struck an arm of the lake, but found no trace of him. A party was sent down the shore, and two other parties to climb the adjacent mountains, to search for him, and to build fires on them to attract his attention. Next morning, no news being heard of him, a council was held and the camp moved to the main lake, and search commenced vigorously, but without avail. The fourth night a snow-storm commenced and continued for two days, rendering the search during that time impossible. The situation of the party was becoming precarious; away from the settlements, no trail, without a guide, and snow covering the ground. Another council was held, and it was determined that it was best to move toward the settlements. Mr. Gillette volunteered to stay and prolong the search, and two soldiers were left with him. Mr. Gillette is one of the best mountain-men of the party, and there is hope that he may bring some tidings of the missing man. On the south end of the lake is a very beautiful collection of hot springs and wells; in many the water is so clear that you can see down fifty or a hundred feet. The lake is 8,000 feet above the level of the sea, a beautiful sheet of water, with numerous islands and bays, and will in time be a great summer resort; for its various inlets, surrounded by the finest mountain scenery, cannot fail to be very popular to the seeker of pleasure, while its high elevation and numerous medicinal springs will attract the invalid. Its size is about twenty-two by fifteen miles.

Leaving the lake, we moved nearly west, over several high ranges, and camped in the snow amid the mountains. Next day, about noon, we struck the Fire Hole River, and camped in Burnt Hole Valley. This is the most remarkable valley we found. Hot springs are almost innumerable. Geysers were spouting in such size and number as to startle all, and are beyond description. Enormous columns of hot water and steam were thrown into the air with a velocity and noise truly amazing. We classified and named some of them according to size:

No. 1. The Giant, 7 by 10 feet, throwing a solid column of water from 80 to 120 feet high.
No. 2. The Giantess, 20 by 30, throwing a solid column and jets from 150 to 200 feet high.
No. 3. Old Faithful, 7 by 8, irregular in shape, a solid column each hour, 75 feet high.
No. 4. Bee Hive, 24 by 15 inches, stream measured 219 feet.
No. 5. Fan Tail, irregular shape, throwing a double stream 60 feet high.
No. 6 is a beautiful arched spray, called by us the Grotto, with several apertures, through which, when quiet, one can easily pass, but when in action each making so many vents for the water and steam.

Upon going into camp we observed a small hot spring that had apparently built itself up about three feet. The water was warm but resting very quietly, and we camped within 200 yards of it. While we were eating breakfast this spring, without any warning, threw, as if it were the nozzle of an enormous steam-engine, a stream of water into the air 219 feet, and continued doing so for some time, thereby enabling us to measure it, and then as suddenly subsided.

Surrounded by these hot springs is a beautiful cold spring of tolerably fair water. Here we found a beautiful spring or well. Raised around it was a border of pure white, carved as if by the hand of a master-workman, the water pure. Looking down into it, one can see the sides white and clear as alabaster, and carved in every conceivable shape, down, down, until the eye tires in penetrating.

Standing and looking down into the steam and vapor of the crater of the Giantess, with the sun upon our back, the shadow is surrounded by a beautiful rainbow; and, by getting the proper angle, the rainbow, surrounding only the head, gives that halo so many painters have vainly tried to give in paintings of the Savior. Standing near the fountain when in motion, and the sun shining, the scene is grandly magnificent; each of the broken atoms of water shining like so many brilliants, while myriads of rainbows are dancing attendance. No wonder, then, that our usually staid and sober companions threw up their hats and shouted with ecstacy at the sight.

We bid farewell to the geysers, little dreaming there were more beyond. Five miles below Burnt Hole we found the "Lake of Fire and Brimstone." In the valley we found a lake measuring 450 yards in diameter, gently overflowing, that had built itself up by a deposit of white sub-strata at least 50 feet above the plain. This body of water was steaming hot. Below this was a similar spring, but of smaller dimensions, while between the two, and apparently having no connection with either, was a spring of enormous volume flowing into the Madison, and is undoubtedly the spring about which Bridger was laughed at so much when he reported that it heated the Madison for two miles below. For some distance down the river we found hot springs and evidences of volcanic action. Our passage down the river was a little rough, but generally very pleasant, and on the evening of the 22d we reached the first ranch on the Madison, where we found a paper dated September 1st, the latest news from the inside world. Next day we sent to Virginia for papers, and soon found that the world had been moving.

List of ditches in Montana in the fall of 1869.

Furnished by Aug. Steitz, M. E., of Helena, Montana.

Name.	Owners.	Location.	Length, miles.	Inches, water.	Cost.
MEAGHER COUNTY.					
Boulder	Metcalf & Co	Diamond	8	2,000	$90,000
California	W. Thomas & Co.	Confederate	10	1,200	20,000
Eldorado	Smith & Heanan	do	5	800	10,000
McCune Bar	Merritt, Marshall & Co	New York	3½	600	15,000
Eldorado Bar	Stark Company	Eldorado	5½	1,000	95,000
Marshall					
—— ——	Williams & Co.	Thompson	3	800	3,000
—— ——	do	do	2	600	2,000
—— ——	Association	do	2½	140	1,500
—— ——	Tubbs & Co.	do	½	250	1,500
			40	7,300	238,000

List of ditches in Montana in the fall of 1869—Continued.

Name.	Owners.	Location.	Length, miles.	Inches, water.	Cost.
DEER LODGE COUNTY.					
Rock Creek	Kohn & Co	Pioneer	13	1,500	$60,000
Tom Stuart	Pioneer Company	....do	3	100	1,000
Pioneer	Pemberton & Co	....do	3	700	10,000
Keystone	Colonel Thurston	....do	5	700	10,000
Prouse	Rock Creek Company	....do	2	450	13,000
Pike's Peak No. 1	Kohn & Co	....do	3	400	7,000
Pike's Peak No. 2	......do	....do	3	300	3,000
Caruthers	George Caruthers	....do	3	300	5,000
Enterprise	Pemberton & Co	....do	3	250	5,000
Last Knob	......do	....do	2	200	2,500
Dutchman	Meagher Company	....do	3	300	5,000
Tiger	Pemberton & Co	Blackfoot	3	600	10,000
Ohio	Pounds & Green	....do	15	800	30,000
Snowshoe	Kelly & Co	....do	3	500	4,000
Pryor	Pryor & Johnson	....do	3	200	1,500
Johnson	Johnson & Co	....do	3	200	3,0°0
California	Thornton & Preston	French Gulch	5	600	20,000
Bear Creek	Domingo & Co	....do	7	300	6,000
American	Weare & Co	....do	2	200	2,500
Moose Creek	Lebeau & Co	....do	2	150	2,000
Mill Creek	P. Golden & Co	Mill Creek	2	700	3,500
Minnesota	Harris & Co	German Bar	15	500	40,000
Beefstraight		....do	5	300	2,000
German Gulch	Stone & Co	....do	4	300	8,000
Highland		Highland	5	500	10,000
Blacktail	—— Shoup	Blacktail	6	500	6,000
Humphrey & Allison	Humphrey & Allison	Butte	25	600	40,000
Noyes	John Noyes	....do	5	500	4,000
Silver Bow and Rocker	Vanderberg & Co	Rocker	3	1,000	10,000
Divide Creek No. 1	L. A. Barnard & Co	Silver Bow	23	400	40,000
Divide Creek No. 2	......do	....do	15	300	5,000
China Ditches, 2	Chinese	....do	4	400	7,000
Oro Fino	Morely & Co	....do	6	500	10,000
Eight Mile	Bob Linder & Co	Lincoln	8	500	12,000
Stonewall		....do	12	500	12,000
Washington	Kelly & Co	Washington	12	500	40,000
Dalton	P. Dalton & Co	....do	3	300	3,000
Henderson		Henderson	4	500	5,000
Georgetown	Jameson & Co	Georgetown	4	3 0	3,000
Oro Fino	J. Allport	Cariboo	3	500	10,000
Cariboo	......do	....do	3	200	2,500
California	Jackson & Co	Jefferson	3	200	5,000
—— ——		....do	3	250	3,000
McLellan		McLellan	3	200	2,500
Standifer	Wilson & Co	Standifer	6	300	6,000
Miner's		Elk Creek	3	200	2,000
Prairie Bar	Frederickson & Co	Prairie	3	200	3,000
Uncle Ben		Uncle Ben	6	250	3,000
			279	20,350	498,000
LEWIS AND CLARKE COUNTY.					
Big Helena	Truett & Atchison	Last Chance	14	800	$110,000
Yaw Yaw	......do	....do	5	2,500	25,000
Taylor, Thompson & Co	......do	....do	6	120	4,000
Nelson	Pierson & Spiers	Nelson	4	150	6,000
—— ——		....do	5	100	5,000
Divide	Ralls & Co	Quartz Gulch	4	75	3,000
—— ——		Greenhorn	2	50	2,000
Piegan	Piegan M. Co	Piegan	7	400	15,000
Trinity	Behm & Co	Trinity	7	600	16,000
Gravelly Range	E. M. Dumply	Gravelly Range	17	200	15,000
Park	J. S. Hutchinson	Park	4	100	6,000
Milay	Milay & Co		4	50	4,000
French Bar	French Bar Ditch Co	French Bar	24	200	30,000
Central	Taylor, Thompson & Co	....do	25	1,100	48,000
Twenty-two small ditches	Sundry	Sundry	44	1,200	35,000
			172	7,705	324,000
BEAVER HEAD COUNTY.					
—— ——	B. Ditch & M. Company	Bannack	15	*2,000	$15,000
—— ——	......do	....do	30	1,000	35,000
White's		....do	3¼	800	25,000
Cañon		....do	6	......	7,000
Pioneer		Bald Mountain	10	600	5,000
—— ——	Yearian Bros	Horse Prairie	15	1,000	15,000
North Side		Bannack	4	8 0	4,000
			83¼	6,200	106,000

CHAPTER VI.

UTAH.

The past year witnessed a sudden and extensive development of mining in this Territory. As long ago as 1863 General P. Edward Connor, in command of the California volunteers, discovered veins of argentiferous lead and other silver ores in Little Cottonwood Cañon, southeast of Salt Lake City, and near Stockton, forty miles southwest; and gold placers of moderate richness were opened in Brigham Cañon. The opposition of the Mormon authorities, the cost of transportation, and the difficulty experienced in the treatment of the "base-metal" ores, caused the earlier mining enterprises of Utah to languish and fail. In 1868 and 1869, I found no mines in productive operation excepting the placers of Brigham Cañon, which were worked on a small scale, and are said to have yielded during the past three years between $600,000 and $1,000,000. In 1869, however, a few parties were preparing to take advantage of the facilities offered by the railroad; and experiments of a metallurgical character were in progress at Salt Lake City. It was the development of the Emma mine which gave the needed impetus to enterprises of this kind; and the summer of 1870 effected a great change in the condition and prospects of Utah mines. The opposition of the Mormon authorities has apparently been withdrawn. Indeed, one reason, shrewdly given me by Mr. Brigham Young, three years ago, for discouraging the attempts of his people to engage in mining, has now ceased to exist. During the infancy of the Mormon settlements, he said, and while the very existence of the community depended upon agriculture, he professed to dread the diversion of industry from the great work of reclaiming the desert soil. He might well have quoted the case of Captain John Smith and the colony at Jamestown, Virginia, as an instance of the folly of such a course; only, in that case, after the colonists had wasted the season in digging gold dust, neglecting meanwhile to plant their crops, and had sent their ship-load of shining treasure to England, they had nothing to comfort them in their famine but the tidings that their precious cargo was not gold at all, but glittering mica, (and possibly pyrites;) whereas the mineral resources of Utah are not a vain dream. But agriculture was to the Mormons not only the means of supporting life; it was a source of great commercial profit. Far into the mining districts of other Territories went the Mormon trading-trains, carrying grain and vegetables; while the endless procession of immigrants across the continent paid tribute on the way to the farmers of Salt Lake. A third reason for dislike to mining on the part of the religious authorities may have been the fear of contact with outnumbering Gentiles.

The completion of railway connections with the East and West has totally changed the situation. The Mormons are no longer commercially isolated; they have lost their control of interior traffic; the market close at hand of a mining population is welcome to them in a business point of view; their agriculture and their population are too well established to be in danger from the new industry; they can no longer help themselves if they would; and, finally, they have to a considerable extent caught the prevailing fever, and are locating and prospecting ledges with truly Gentile zeal. Mr. Young is said to be encouraging

the movement; and the party in his church hostile to him is vigorously engaged in furthering all mining enterprises.

I intend to present in my report for next year the results of a careful reconnaissance of these new and productive districts; and I shall content myself at present with brief general observations. I am under obligations to Messrs. Eli B. Kelsey, Ellsworth Daggett, and others for interesting information on several points.

The following account of different districts was furnished in December, 1870, by Mr. Kelsey:

The minerals consist mostly of the base metals, of which lead is the chief, carrying silver, and in some cases gold, in quantities varying from a few ounces to one hundred and fifty ounces of the former metal to the ton. Valuable discoveries have been made of chlorides and "horn-silver" of surprising richness, varying in actual assay value from $500 to $27,000 per ton. Assays have been had from the ore taken from the Silveropolis mine in East Canyon, owned and worked by Messrs. Walker Brothers and others, of $20,000 per ton. Shipments of a number of car-loads of ore have been made from this mine that yielded a net return of $6,666 per car-load of ten tons.

Ore has been taken from the Shamrock mine in East Cañon, that assayed as high as $27,000 per ton. This mine is owned and worked by Mr. William M. Fliess, Mr. William C. Rodgers, merchants of New York City, Mr. W. S. Godbe, of Salt Lake City, and others. Shipments have been made from this mine which have given returns of from $1,800 to $5,600 per ton. I speak of these two mines as an evidence that, although nine-tenths of the mineral veins yet prospected in Utah show the base metals, lead and copper, we are not without the richer ores.

History of the mining-camps.—The mineral developments in Utah are still in their infancy, and but few mining-camps have as yet been established. The following districts are fully organized and in a very prosperous condition:

The "Mountain Lake" district, of which Little Cottonwood Cañon forms the chief feature, lies southeast of Salt Lake City, and distant about twenty-five miles from the terminus of the Utah Central Railroad.

The first fully developed mine in Utah, the "Emma," is in this cañon. In fact, the results attained in the development of this mine gave an impetus to mining in Utah that surpasses all other efforts made in that direction put together. At a depth of 127 feet the prospectors of this mine struck a lake of mineral of vast extent, which now yields a clear profit on shipments made to Swansea, in Wales, of near $120 per ton. Many thousands of tons of ore (by measurement) are in sight in this mine, undoubtedly of equal richness to that now being shipped. There are many mineral lodes now being worked in Little Cottonwood and the adjacent cañons—Big Cottonwood and American Fork—which yield ore equal to, and in some cases far exceeding in value, the ore taken from the Emma mine, but in quantity the Emma has no equal in Utah.

The Union Mining Company, of which General Maxwell is president, W. S. Godbe vice-president, and H. W. Lawrence treasurer, own a large number of valuable ledges in Little Cottonwood, which they are opening rapidly and very effectually. Mr. John Cummins, of Salt Lake City, is owner of several valuable mines in the same locality.

West Mountain mining district, of which Bingham Cañon and its tributaries form the chief feature, is situated about twenty-five miles southwest of Salt Lake City, on the eastern slope of the Oquirrh range of mountains. Bingham Cañon has been noted for some years as the only locality in Utah Territory where placer-mining has prospered. Over $600,000 worth of gold dust has been sold to the bankers and merchants of Salt Lake City from this camp within the last three years. When the sums carried away and otherwise disposed of by the miners are taken into account in making up an estimate, the sum-total of the yield in gold dust from Bingham Cañon placer for the last three years will not fall far short of $1,000,000.

Messrs. Taylor & Woodman have entered into contracts with the owners of near three miles of the gulch-claims of this cañon, to put on the necessary engines and pumps for the prospecting and working the bed-rock of the main gulch, which lies from 80 to 100 feet below the surface. The best-informed parties think that the gulch bed-rock of Bingham Cañon will prove equally as rich as the famed "Alder Gulch" of Montana. Messrs. Taylor & Woodman have imported and have now on the ground a twenty-horse engine and the necessary pumping apparatus for exploring the mysteries of Bingham Cañon Gulch.

Messrs. Heaton, Campbell & Co. are now working the bed-rock of this gulch, near the mouth of Carr Fork, which they have reached, after two years' labor and the expenditure of $15,000, by a long drain-tunnel. They inform me that they are averaging $12 per day to the hand, notwithstanding the imperfect manner in which they are at present obliged to work their ground. They have not, as yet, run any side-drifts, and at present raise all their dirt by a windlass worked by two men. When we take

into consideration the fact that from the "pay-dirt" excavated by one drifter enough gold is washed to pay six hands $12 per day each, or a total of $72, abundant evidence is given that the gulch of Bingham is very rich in gold.

The mineral lodes in Bingham Cañon and its tributaries are very numerous, continuous, and well defined. They are mostly found in the igneous formations. The various species of the granite and quartzite rocks characterize the mineral-bearing region of the West Mountain mining district so far as prospected. The belt of igneous rocks, or core of the upheaval, traversing Utah from northeast to southwest, is nearly twenty miles in width. The granites appear at the base of the Wahsatch Range, east side of Salt Lake Valley, and disappear near the head of all the northwest forks of Bingham Canyon.

What the experiences of the future may demonstrate no one can tell—"*the miner's light but seldom going beyond the end of his pick.*" So far, however, as explorations have gone in the various mining-camps now organized in Utah, and in which the chief part of the labors expended in prospecting our mineral treasures has been performed, the fact that the richer chlorides, and that mining anomaly "horn-silver," prevail in the lime formations, has been demonstrated. The mineral veins found in the lime formations are "*pockety*" and of uncertain development when compared to those found in the granite formations. That the richer ores will be found in the lime formations may, therefore, be looked for hereafter; but for large, well-defined mineral veins, continuous and of more certain development, we must look to our granite formations. Pockets of great extent and richness have been found in the lime formations of Little Cottonwood and other localities. There are quite a number of mineral veins now being prospected in Bingham Cañon at depths varying from fifty to over three hundred feet, which show true fissure veins of paying ores varying from four to seventeen feet in thickness.

Stockton district.—These camps lie on the western slope of the Oquirrh range of mountains—Stockton forty miles, and East Cañon fifty-five miles southwest of Salt Lake City. Stockton is probably the oldest camp in Utah. General Connor, when in command of the Utah expedition of the California volunteers, bestowed the chief part of his labors in the development of the minerals of Utah in this locality. The great drawbacks experienced by this camp have mainly arisen from the fact that most of the ledges located had from six to twelve shareholders each, who, after years of fruitless efforts to develop their mines, scattered to all points of the compass in search of means to sustain themselves. At the time those explorations were made, it was impossible to make mining a success in Utah, for the following reasons:

The cost of transportation, before the completion of the Pacific roads, varied from $300 to $400 per ton to the Atlantic coast, and from $250 to $300 per ton to the Pacific coast. Without the facilities afforded by the great iron highway across the continent, the mineral treasures of Utah would to-day be utterly unavailable. The impossibility of securing concert of action from the widely scattered owners and prospectors of the mineral lodes in the Stockton district induced a minority of the shareholders to adopt the dangerous expedient of "jumping" the claims of absentees, thus rendering titles to mining interests in that locality uncertain. However, numerous discoveries of mineral veins, many of which prospect very finely, have been located since the "jumping" of claims, before alluded to, took place, the titles to which are as clear as any in Utah. New discoveries are being made almost daily in this district.

General Connor's faith in the ultimate success of the Stockton district remains unshaken. He is better acquainted with the mineral resources of the Territory and has done more toward their development than any other one man.

Ophir district.—East Cañon mining camp is less than six months old. In this camp the discoveries of the rich chlorides and horn-silver, assaying from $500 to $27,000 per ton, turned the heads of some of the oldest miners and filled the pockets of the fortunate ones as well. East Cañon abounds with the base metals carrying silver in paying quantities. In those base-metal mines lies the "back-bone" of the future of this camp.

The Tintic Valley mining camps are situated about seventy miles southwest of Salt Lake City. The core of the upheaval, traversing Utah from northeast to southwest, runs through the Tintic mining district, flanked on each hand by the lime formations. Therefore we look to the Tintic district not only for large, continuous, and well-defined mineral veins of base metals in the granite formations, but the reasonable supposition is that, by prospecting the lime formations on either hand, the rich chlorides will be found as plentiful there as in the Wasatch Range or the western slope of the Oquirrh Range. Valuable discoveries are being made in the Tintic district almost daily. A friend of mine brought a load of ore from Tintic, evidently selected without skill, as the croppings from the surface were included. This load of ore, when crushed and sampled at the works of Messrs. Howland & Co., assayed $117 per ton in silver and 25 per cent. lead.

The only thing now wanting to make Tintic one of our most flourishing mining dis-

trict is capital, to enable the miners to prospect their lodes and erect smelting furnaces for the working of their ores on the spot, and thus save the heavy freightage now paid on crude matter to Salt Lake City.

The Mount Nebo district eighty miles, the *Sevier district* two hundred miles, south of Salt Lake City, and the *Meadow Valley district* two hundred and forty miles southwest of Salt Lake City, are rich in minerals.

Mr. Kelsey's statements are indorsed by Messrs. Gould & Woodward, Walker Brothers, Kimball & Lawrenc, Godbe & Co., Marshall & Carter, and Kahn Brothers, merchants of Salt Lake City, and by Vernon H. Vaughn, the governor, and C. H. Hempstead, the United States attorney of the Territory.

Estimate of costs of mining ores in West Mountain district, Salt Lake County, Territory of Utah, reported by Eli B. Kelsey, December 20, 1870.

Population of district, 400 souls; wages of first-class miners, $3 per day; wages of second-class miners, $2 50 per day; wages of surface laborers, $2 per day; cost of lumber, $4 per 100 feet; cost of mining timber, $6 per cord; cost of common powder, $5 per keg; cost of quicksilver, 80 cents per pound; cost of freight from Salt Lake City, $15 per ton; cost of fuel, wood, $4 per cord; mining cost per ton of ore, $5 per ton, (average facilities poor from total want of machinery;) depth of mines, from 100 to 400 feet; character of rock, etc., granite, quartzite, and hornblende; reduction, smelting a failure as yet—no mills.

REMARKS.—Our mining developments are yet in their infancy. The number of mineral veins is very great, with well-defined wall-rocks in all those yet worked. Veins from one foot to fifty feet in thickness. The mines in Bingham Cañon and its tributaries, which comprise the West Mountain mining district, are mostly base-metal mines, carrying from 10 ounces to 150 ounces of silver to the ton of 2,000 pounds. There are several mineral veins of gold and silver bearing quartz, none of which are developed to any considerable extent; one of them, the Silesia, gives an average assay of $50 per ton. There are no stamp-mills in the Territory except one or two small ones in Meadow Valley. A great number of quartz-mills are contracted for, to be delivered here in the spring, mostly for East Cañon, Rush Valley, fifty miles southwest of Salt Lake City.

Messrs. Walker Brothers report having shipped during the six months ending December 31, 1870, 4,200 tons of galena ores, of an average assay value of 35 per cent. of lead and $182 in silver per ton, the net value being $125 per ton. Almost all of this was from the Emma mine.

The following are the prices reported in January, 1871, as paid in Salt Lake City by California buyers for Utah ores: Ore containing 50 ounces silver and 30 per cent. lead, per ton, $22; 50 ounces silver and 40 per cent. lead, per ton, $30 60; 50 ounces silver and 50 per cent. lead, per ton, $38; 50 ounces silver and 60 per cent. lead, per ton, $45; 50 ounces silver and 70 per cent. lead, per ton, $53; 50 ounces silver and 80 per cent. lead, per ton, $61.

In addition to the above rates, $10 per ton, additional, is paid for each 10 ounces of silver over 50 ounces per ton. Every tenth sack of ore is crushed and sampled for assay, and the ore is paid for as soon as assayed. This ore is all shipped to San Francisco and is there smelted, and the lead as well as the silver is made a marketable commodity.

Almost all the Utah ores have, however, been, up to the end of 1870, shipped east over the Union Pacific. The amount is given by the San Francisco Scientific Press as follows:

	Tons.		Tons.
January	3,441	September	724
February	31	October	590
March	95	November	541
April	172	December; not received.	
May	204		
June	3,030	Total	9,633
July	511		
August	294		

Which must, however, include shipments of ores and matte from Colorado, and perhaps Nevada.

I am indebted to Mr. Charles Smith, of the Emma Silver Mining Company, for the following statement of shipments of ore and bullion over the Utah Central Railroad, from January 13, 1870, to December 31, 1870. These figures are taken from the way-bill records of the road, by courteous permission of D. O. Calder, esq.

2,968 tons of ore were shipped east to Chicago, Boston, Newark, and New York.

2,325 tons of ore were shipped west to San Francisco, Reno, and Truckee.

Total, 5,293 tons of ore.

The bullion shipments of the same period were 2 tons to England, and 6½ tons to San Francisco.

These totals may seem small to some, but it must be remembered that the Emma Silver Mining Company, which forwarded the largest portion of it, did not commence shipping until July, 1870. These shipments are therefore really the product of six months, rather than a year.

Estimating the value of the ore shipped at $182 per ton (the value of the 4,200 tons shipped by Walker & Co. from the Emma mine) and that of the bullion at $400 per ton, we have $966,726 as the probable value of the shipments by railroad. Allowing, further, $300,000 for the gold of Bingham Cañon, and a small sum for private shipments not way-billed, we have, as the probable product of Utah, for the year 1870, the sum of $1,300,000. In this estimate the Meadow Valley mines are not included, as they are now generally acknowledged to lie within the boundary of Nevada.

A correspondent writing from Salt Lake early in the autumn thus reviews the mining field:

Utah makes quite a show in the way of minerals. Iron ore is known to exist in several places in large amounts. In Iron County works were built in 1852, and a small quantity of ore was smelted, but want of proper fuel compelled a suspension of operations. The Union Iron Company had two furnaces in operation in January, 1869, and one in the course of construction. Coal has been found in quite extensive beds, but principally in the neighborhood of Coalville, Summit County. Copper, lead, silver, zinc, and sulphur occur, and different sorts of building stone abound. The mines at the Little and the Big Cottonwood Cañons, twenty-eight miles southeast of Salt Lake City, are the center of the present mining excitement. Communication is had with these places by a stage, which runs three times a week. The largest mine at Little Cottonwood is the Emma ledge, located in August, 1868. In July, thirty-one car-loads of ore were shipped from the ledge, and that month upward of $3,000 were paid for hauling. The cost of transportation (by team to Salt Lake City, and thence by rail) to New Jersey, and the expenses of treatment, amount to $90 per ton, but the ore sent averages, I am told, nearly $200 per ton. There are twenty men employed here extracting the rock, of which some fifteen tons are obtained daily. A tunnel is

being run in to tap the main shaft, which is down about 200 feet. I send you a specimen of the ore. There are other promising locations, as the North Star, owned by Bruno & Co., and the Western State, which takes out some twenty tons weekly. Not far off, over the ridge, is Big Cottonwood Cañon. Here the Empire Tunnel Company propose torun a tunnel in toward Little Cottonwood. Here are also the Wellington, Theresa, Davenport, and other leads. The general formation is limestone. Mr. C. L. Stevenson, who has lately visited the various mining districts, gives me the following approximate product of the different mining localities during the month of July. The average value of ore exported was about $105 per ton:

	Tons.
Little Cottonwood	314
Bingham	6
Parley's Park	40
Rush Valley	70
Deep Creek	10
Tintic	30
Total	470

Smelting works.—Messrs. Woodhull Brothers have built a furnace here, and have made the first run of this Territory. This run created, naturally, considerable excitement here. The result was a production of 5,000 pounds of bullion in thirty-six hours. This assays about $500 to the ton in silver. The metal was hauled to town, and stocked up in front of the Elephant store, where it attracted large numbers of people who were curious to see the pioneer bars of Utah. The Woodhull Works are capable of working about ten tons daily. Mr. Milton Robbins is about to put up smelting works. He will have the able assistance of Mr. Charles C. Ruegar, who will take the active management and the construction of the furnaces in hand. Mr. Ruegar has studied in Germany, and has spent considerable time among the mines of California. He appears to be well fitted for his work. Mr. Leopold Balbach, a cousin of the Balbach Brothers, of Newark, New Jersey, has been visiting the mines of Utah, and was so impressed with their extent and richness that he telegraphed to parties East (he tells me) that he thinks best to erect smelting works in the valley, and these are to be put up. There are others here who engage in buying ores, and the mines are attracting persons from different quarters. There seems to be every reason to suppose that Utah contains valuable mineral deposits, and probably these will be developed quite extensively henceforth.

The facts seem to be that the most productive mines working up to the close of 1870 are masses or "stock-works" of argentiferous galena in limestone; that the business of mining and reducing or shipping the ores is one that requires considerable capital; and that the abundance of supplies, cheapness of labor, and facility of transportation render this a highly inviting field for operations on a large scale. That the sanguine expectations of the owners of thousands of locations will be fulfilled, it would be foolish to predict; but it cannot be denied that the actual progress already made, and the favorable economic conditions attending the new industry, give unusually good ground, even for speculative anticipations.

CHAPTER VII.

ARIZONA.

The present chapter is based chiefly upon the notes of Mr. A. Eilers, my deputy, who has also arranged and edited the material contained in it from other sources. Besides those citizens to whom Mr. Eilers acknowledges in these pages his indebtedness for valuable assistance, thanks are due in an especial manner to Hon. Richard C. McCormick, delegate of the Territory in Congress, who contributed in many ways, including advice, information, time, personal exertions, and money, to facilitate the examinations which Mr. Eilers was charged to make. Without the influential and energetic support of Mr. McCormick, and, I should add, of Hon. A. P. K. Safford, the public-spirited governor of the Territory, it would have been vain to attempt so laborious and perilous a task with the time and means at my disposal.

The act of February 24, 1863, creating the Territory of Arizona, describes it as comprising all the United States lands west of the one hundred and ninth degree of longitude to the California line, which, before that time, had belonged to the Territory of New Mexico. Since then the portion of Pah-Ute County lying west of the Colorado River has been ceded to Nevada, but at the present writing it has not been legally accepted by that State, and the inhabitants are in favor of reunion with Arizona. Presuming, however, this cession to be an accomplished fact, the present boundaries of the Territory are as follows: On the east, the one hundred and ninth meridian of longitude; on the west, the Colorado River, except above the big bend of that river, where the one hundred and fourteenth meridian of longitude forms the western line; on the north, the thirty-seventh parallel of north latitude; on the south, the boundary line between the United States and Mexico.

The total area of the Territory is given as 105,120 square miles. It joins on the west California and Nevada; on the north Nevada and Utah; on the east New Mexico; and on the south the State of Sonora, of the Mexican republic.

Arizona is divided into five counties, Yuma and Pima in the southern, and Pah-Ute, Mohave, and Yavapai in the northern and middle portions of the Territory. Yavapai is by far the largest county, and its northern and eastern parts are almost unknown at the present time. Prospecting parties have, from time to time, ventured to enter these regions, but were invariably driven back by the hostile Indians before penetrating far into the interior, and Government expeditions have only in a few instances penetrated small belts of that domain. The whole vast Territory of Arizona is drained by one single river and its tributaries, the Colorado of the West. This river is formed by the junction of the Green and Grand Rivers, which join in the southern part of Utah Territory, and rise, the one in the Rocky Mountains, a short distance north of the Great South Pass, the other in the Middle Park of Colorado Territory. The Colorado River, although it drains an enormous area, and sends a vast body of water to the Gulf of California, is only navigable for a distance of about five hundred miles, and here only for boats drawing very little water. It has a very rapid current, and carries along large masses of the soft materials that form the greater portion of its banks from its mouth to the

Black Cañon and those of its tributaries in the Territories above. Thus the navigable channel is often changed entirely in a single night, and the greatest care is required to run steamboats on it successfully. Broad strips of bottom-land skirt its lower part on both banks, with the exception of a few miles, where mountain ranges, such as the Monument Mountains and the Needles, approach to the water's edge.

The principal tributaries of the Colorado, in Arizona, are the Colorado Chiquito or Flax River, the Diamond River, Bill Williams' Fork, into which the Santa Maria River empties, and the Gila, with its affluents, the Rio Salinas, Rio Verde, the San Carlos, and San Pedro. The Santa Cruz from the south, and the Agua Frio and Hassayampa Rivers from the north, sink in the dry plains before they reach the Gila.

The climate of the Territory is like neither that of the Atlantic States nor that of the Pacific coast, but rather stands between the two, exhibiting peculiarities of both. While in the portion south of the Gila River and along the trough of the Colorado River an excessively hot and dry atmosphere prevails, relieved only by the semi-annual showers of January and July, the middle and northeastern parts of Arizona enjoy a climate very similar to that of the South Atlantic States. As a natural consequence, the vegetation of Southern and Western Arizona is scanty and limited to a few genera, such as cactus, aloe, artemisia, palo verde, iron-wood, and mesquite, which can sustain themselves on a parched soil and under the rays of an almost tropical sun. The bottom-lands of the rivers are, of course, an exception to this, the increased moisture and richer soil supporting here a luxurious growth of cotton-wood, willow, mesquite, arrow-weed, and many different kinds of nutritious grasses. The middle and northeastern portions of Arizona are made up of elevated plateaus and an extensive system of mountain ranges, and here a more varied vegetation prevails. The heat is here never oppressive, and even during the hottest summer months the thermometer does not rise any higher than in the Blue Ridge in the Southern States. Greater moisture in the atmosphere stimulates the growth of magnificent pine and cedar forests, and the soil is everywhere covered with beautiful flowers and nutritious grasses. Ash, walnut, cherry, willow, cotton-wood, and many other forest-trees grow along the course of the streams, and large oak-trees are seen on the very tops of some of the highest mountains in the Sierra Prieta.

The agricultural resources of Arizona have been underrated. It is true, the greater portion of the "Gadsden purchase" is made up of sterile waste; of great, sandy plains, and "mal pais" plateaus, in which the "Lost Mountain" ranges can be seen days before the traveler is able to reach them. But even here the valleys of the Colorado, the Gila, the Santa Cruz, San Pedro, Arivaypa, and San Simon contain thousands of acres of the most fertile bottom-lands, which need only irrigation to make them yield abundant harvests. This has been demonstrated in the present generation by the settlers of the Gila, in the neighborhood of Florence and Adamsville, and those of the Salt River Valley, at Phœnix and vicinity, as it was proved centuries ago by the aborigines of that country—now an extinct race. Indeed, the remnants and monuments of that former civilization are so abundant all over Arizona as to leave no doubt that all this vast region was once thickly inhabited by an industrious and thriving agricultural people. The Pima Indians, living at present upon their large reservation near the mouth of the Salt River and along both banks of the Gila above that point, claim that the great "casas," and the large irrigating canals, unmistakable evidence of which still abounds all over the Territory, were constructed by

their forefathers, the Aztecs, and that they themselves are the only tribe left which traces its descent back to that once powerful people. All the agricultural products of Southern California and Northern Mexico, Indian corn, wheat, barley, oats, grapes, figs, oranges, lemons, sweet potatoes, tomatoes, tobacco, the castor-bean, etc., thrive in this southern portion of Arizona, wherever the land can be irrigated. And as to grazing lands, there are millions of acres covered with the best grasses, in many detached parts of the "Gadsden purchase," especially in the southeastern corner of that portion of Arizona; and that country would be covered with cattle-ranches to-day, as it has been when first settled by Mexicans one hundred years ago, were it not for the savage Apache and the insufficient protection which the Government accords to the settlers.

Middle and Eastern Arizona contain much more arable land than the "Gadsden purchase;" but only the different valleys in the vicinity of Prescott are now occupied by white settlers. Prominent among these are the Val de Chino, Walnut Grove, Williamson's, People's, Kirkland's, Skull, Thompson's, and Agua Frio Valleys, the two first alone with an area little less than 1,000,000 acres. Here all the cereals and roots of the Northern Atlantic States are grown, but the high elevation of this part of Arizona, its mountainous character and the late frosts in the spring, as well as those in the early fall, frequently endanger the crops. On the other hand, this region is well supplied with moisture, not alone during the winter months, when much snow falls, without, however, remaining longer than a few days in the valleys, but also during the months of July and August, when copious and rapid discharges of rain occur, filling all the mountain streams, and saturating the plains. As a grazing country this region cannot be surpassed. A thick growth of grama and bunch-grass covers the whole country, not alone the valleys and plains, but the very tops of the mountains, giving to the pine woods of this region the aspect of beautiful natural parks. Of the region east of Prescott, between the Rio Verde and its tributaries and the New Mexico line, little is known. Only the reports of military expeditions and prospecting parties give a clew to the character and topography of small portions of the country, while the greater part remains to this date unexplored. It is reported that many fine valleys exist in the Mogollon Range, the Pinal Mountains, and the Sierra Blanca, and that the greater portion is a good grazing country. Of the extreme northern and northeastern part of Arizona nothing whatever is known, the thirty-fifth parallel being the northernmost route ever traveled by an exploring expedition across Arizona. None of the smaller expeditions branching off from this route penetrated far to the north and northeast, and we know from them only that the country is a vast elevated plateau made up principally of cretaceous rocks, into which deep gorges and cañons are cut by the streams. Some of the valleys of this region, notably those of the Navajoe country, are reported to be fertile and to present conditions favorable for agriculture, while the greater area of the plateau is said to be a fine grazing country.

Many different tribes of Indians inhabit the Territory of Arizona, a few of which are friendly to the whites and live upon reservations, while the greater number are intensely hostile.

Of the friendly Indians, the Pimas, and a small tribe living close to them, the Maricopas, hold the first rank in importance, not alone on account of numbers, but also because they are much more civilized and physically as well as morally a better class of Indians. I have mentioned before that they claim to be the direct descendants of the Aztecs; and if

a splendid physical development of the race, as well as the high state of civilization they had attained when the white people first entered their domain, can entitle them to this distinction, it must certainly be accorded to them. Captain Grossmann, the Indian agent for the Pimas and Maricopas, has made the habits and legends of these tribes a subject of much study and research, and I hope that his investigations may yet determine the correctness or fallacy of their assertions. The Pimas and Maricopas raise annually much more corn, wheat, beans, melons, etc., than they need for their own sustenance, and their stock of horses and work cattle increases steadily from year to year. They are the deadly foes of the Apaches, into whose country they make frequent expeditions, and by whom they are much more feared than are the soldiers stationed in the Territory.

The Papagos are another friendly tribe, and have, like the Pimas, permanent homes. They live south of the Gila, and their villages are scattered along the line of Sonora, in the valleys of the Santa Cruz, Sonoita, etc. They devote their energies principally to stock-raising, of which they own large herds. They, too, are continually at war with the Apaches and remain the steadfast friends of the whites.

The Mojaves are a powerful tribe, living along the Colorado River above La Paz, their principal villages being located between the Chemehuevis Valley and Fort Mojave. They support themselves by agriculture like the Pimas, but cultivate neither as much nor as good land as the former. Their stock of working cattle and horses is limited, and the irrigation of their lands is attended with much difficulty. The tribe is physically a very fine one, but stands morally far below the Pimas.

The Yumas, Cocopas, and Chemehuevis are three small tribes living upon the Lower Colorado, none of which deserve more than mention. The Utes on the Upper Colorado, the Moquis and Navajoes in Northeastern Arizona, complete the list of friendly Indians. The latter are a very important and rich tribe.

Of the hostile Indians in Arizona, the Apaches are the most powerful and dangerous to the country. They have always been the enemies of the Mexicans, and their raids into that republic often extend as far south as Durango. Up to 1859 they lived at peace with the Americans, but since that time they have waged a relentless war upon all whites. They are not a brave tribe, always avoiding an open fight, in marked distinction from the Indians of the northwestern plains. They invariably attack small traveling parties and trains from ambush, and these only when there is no possible chance of failure. Their sole object of attack is apparently plunder, and to get this they murder those in the way of accomplishing their object. Their raids, always conducted in small parties of generally less than one hundred warriors, extend all over the Territory of Arizona, with the exception of a narrow strip of country along the Colorado River, and a hundred miles of the Lower Gila. The nation is divided into several tribes, the Pinal-Apaches, the Tontos, Coyoteros, and Apache-Mojaves. The Pinal-Apaches live in the Pinal Mountains, southwest of the Mogollon Range; the Tontos on the Tonto Plateau, between the Agua Frio and Rio Verde; the Coyoteros in the southern foot-hills of the Mogollon Range and the Sierra Blanca; and the Apache-Mojaves west of Prescott, in the Aztec Range, their principal rancherias being on the Santa Maria River, which empties into Bill Williams's Fork. It is thus seen that the Apaches are distributed over the greater portion of Middle and Eastern Arizona, and their roving habits tend still more toward bringing them into frequent collision with the white settlers and the peaceable Indians all over the Territory. They are very much feared

and hated by both whites and Indians, but the frequent expeditions against them are generally rather barren of results. It is difficult to get them to fight a respectable number of armed men, and on the approach of the various expeditions organized against them they have almost invariably scattered through their mountain fastnesses, where it is in vain to follow the small bands of five or ten who remain together. These Indians have done more to retard the settlement of Arizona and the development of her mines than all other causes. As soon as a miner's camp was formed within their range, they would hover about until they had stolen the last of the working-stock and killed or driven off the last one of the miners. Very few mining-camps have been able to outlast this continual danger, and those that have so far withstood the Apaches have done so at a fearful cost of property and human life. So long as this tribe is allowed to roam all over Arizona, it is in vain to expect that any settlements can permanently maintain themselves.

Besides the Apaches, the Hualpais or Wallapis, living in the Cerbat Range, near the Diamond River, and in part of the Aquarius Range, are the only dangerous Indians. This tribe has come into the forts during last summer, professing to be tired of war, and suing for peace. Since then they have really been friendly; the portion living in the Aquarius Range alone having committed some new depredations. Should they remain peaceable, some of the most promising mining districts in the Territory would be opened.

GENERAL GEOLOGY OF ARIZONA.

It is not within the province of this report to give a detailed and connected description of the geology of Arizona; nor were the means and the time at the disposal of Mr. Eilers, during his visit in that Territory, sufficiently ample to enable him to make more than a cursory examination of the routes traveled over, and a more extended one of the mining districts proper. His observations extended from Fort Yuma over the Gila River route to Maricopa Wells, and thence to Tucson, from Tucson to the Gila, at Adamsville and Florence, thence to the Salt River at the upper crossing, to Camp McDowell, Phœnix, Hassyampa Cañon, Wickenburg, Camp Date Creek, Kirkland Valley, Skull Valley, Prescott, the greater part of the Sierra Prieta from its northern terminus, the Granite Mountain, to its southern extremity, the Bradshaw Mountain, including all the mining districts of this range; from Prescott by the northern or Mojave road to Camp Tollgate, thence through parts of the Aztec and Aquarius Ranges to the Cerbat and Black Mountains, thence to the Colorado River at Fort Mojave, and down that river to La Paz, thence east to Wickenburg and back to Tucson. For other portions of the Territory, notably the country along the Great Cañon of the Colorado, the Colorado Chiquito, and parts of the country north and east of the same, I have freely used the excellent report of Professor Newberry; and for that portion of the country lying north and east of Tucson, along the line of the thirty-second parallel road, that of Dr. Thomas Antisell. The lowest portion of Arizona Territory, topographically, is the region in the vicinity of the mouth of the Gila River, as a glance at the map and the river system of the country suffices to show. The elevation above the sea-level, at Fort Yuma, is only 200 feet. From here eastward, an apparently level country, but rising gradually and imperceptibly, extends to the line of New Mexico. From this plain rise isolated mountains and mountain ranges, suddenly and without that gradual elevation which a series of foot-hills impart

to mountains in other countries. No valleys, as generally understood, lie between these "lost mountains," but the level, sandy plain extends directly and with nearly the same level from the foot of one mountain to that of the other. This peculiar configuration of the surface is also met with on the La Paz and Wickenburg road, and for a considerable distance along the road from Fort Mojave, toward Prescott; also along the entire length of the road from Tuscon to Wickenburg and some distance north of that town. All the main mountain chains have here a northwest and southeast trend, and the only exceptions to this general direction are furnished by the Black Mountains and the Cerbat Range, in the northwestern corner of the Territory, the axis of their upheaval running very nearly north and south.

In Middle Arizona, especially in the Prescott country and north of it, around the San Francisco Mountain, the surface wears a different aspect. The Sierra Prieta and the Aztec Range send foot-hills out in every direction, and especially their flanks sink very gradually down to the level of the high plateau surrounding the San Francisco Mountain toward the northeast and to the mesas sloping toward the Colorado on the southwest. The country here has attained a considerable elevation above sea-level, the town of Prescott, located in the valley of Granite Creek, near the northern terminus of Granite Mountain, being over 6,000 feet above the sea, while the Tonto and San Francisco plateaus to the east and northeast of Prescott reach an altitude of from 8,000 to 9,000 feet. The San Francisco, a grand volcanic cone, is the highest mountain in Arizona, its top towering over 11,000 feet above the sea. North and northeast of the San Francisco an immense mesa, increasing in altitude toward the Navajo country and the Utah line, stretches for hundreds of miles.

The Mogollon Range, in the eastern part of Arizona, presents the most marked exception to the general northwest and southeast direction of the mountains. Its axis runs very nearly east and west, and joins the Sierra Blanca, also an east and west range, which extends beyond Arizona into New Mexico. The plains along the Lower Gila are entirely made up of Quaternary and Tertiary deposits, which also form the Great Sonora Desert to the south of that stream. The first mountains which the traveler meets on his way up the Gila, after leaving the granitoid knoll on which Fort Yuma is located, and through the middle of which, singularly enough, the Colorado runs at present, are those in the neighborhood of Gila City. Their low foot-hills contain the gold-placers, which at one time caused considerable excitement, and have been again worked since last summer by a San Francisco company. They are sixteen miles east of Fort Yuma, and appear to be the southern continuation of the Castle Dome Range on the north bank of the river, having, like the first, a northwest and southeast trend, and being separated from it by the Gila River and low foot-hills, which on both banks of the river are made up of the same materials, namely, granitic rocks and metamorphic slates, the latter leaning against the foot of the more elevated ridge, which is entirely composed of syenite. The slates of the foot-hills stand almost vertical, and are much contorted, containing a great number of quartz-bands, running in all directions. The low hills immediately at the river-bank are entirely denuded of gravel, while those nearer to the main ridge are thickly covered with angular granitic and slate detritus. East of these hills no more mountains are encountered until, twenty-eight miles farther over a large sandy plain, Antelope Peak is reached. This mountain rises about 500 feet above the level of the Gila, and presents an abrupt, almost vertical face toward that river. It

is entirely made up of a coarse quartzy conglomerate and of brown micaceous sandstone, which in many places seems to be metamorphosed and becomes jasper-like. No fossils were observed. At the foot of the precipice mentioned above lie large masses of the conglomerate broken off from above and scattered in all directions. Nothing of interest breaks the monotony of the river-bottom and the terraced mesa above, until the Big Horn Mountains are reached, which consist of the same materials as Antelope Peak, but they repose here on a granitic basis. Northeast of these mountains, on the opposite side of the river, occurs a hot spring at the foot of a series of erupted hills, which is much visited by invalids. It is located on Colonel Woolsey's ranch, and is well known throughout Arizona. Fourteen to sixteen miles east of this place the traveler enters on one of the most extensive volcanic overflows met with in Arizona. It is thirty-five miles broad from west to east, and extends for a much greater distance from north to south. The material is a dark basaltic lava, which covers the plateau to the depth of from 2 to 25 feet. The Gila River has cut through this overflow from east to west, and this cañon, as well as several side cañons, across which the road leads, afford a fine opportunity to study the formation. In nearly every place where the lower edge of the lava is exposed, a thin layer of yellowish white soft sandstone is found underlying it. It contains no fossils. This sandstone occupies evidently a vast portion of Southwestern Arizona. I have found it on the plains north of the Salt River, and also north of Florence. It is difficult to determine the source of the enormous mass of eruptive material which covers the plain; for although it is certainly slightly inclined toward the southwest, and several cones are visible at a distance north of the Gila, to which the lava extends, and in the neighborhood of which the hills, too, are capped with thick layers of the erupted material, it is difficult to imagine that these floods could have traveled sixty or seventy-five miles without cooling, and the overflow may have come, at least in part, from the southeast, where in the distance several crater-shaped mountains are also visible. The lava plain is broken in one place by several hills, through a cañon of which the road leads, and where whitish trachytes, containing much olivine in the seams, and red porphyries are exposed to view. On the basalt mesas, the "mal pais" of the Mexicans, the *Cereus giganteus*, is found in abundance, and in beautiful specimens.

To the east the road leaves now the river and passes across a peninsula formed by the Sierra Estrella and the Gila River for forty-five miles, where it reaches the Maricopa Wells. The Sierra Estrella consists principally of syenites, which are sunburnt and dark on the outside. Looking at the outline of the crest of a part of this range from a certain position to the east of it, it shows a striking resemblance to a man's head. This is called Montezuma's Head by the Pima Indians.

Above Maricopa Wells the road strikes the river again at the Pima villages. Here the Gila has formed very extensive bottom-lands, which stretch away to the cañons, where the Gila breaks through the Pinal Mountains, a distance of about thirty-five miles. At Sacaton the Tucson route leaves the Gila in a southeast direction. The whole distance to that place the road leads over a level country, consisting of gravel and sand mesa, which is only in a few places broken through by syenitic and porphyritic upheavals, viz, between Sacaton and Bluewater, where in the cañon gneiss is exposed besides syenite, and at the Picacho and the point of the mountain, both composed of a reddish trachytic rock. East of Tucson the mesa is traversed by several extensive mountain ranges, the most important of which are the Sierra Catarina, the Sierra

Calitro, and the Pinal Range, the continuation of which toward the south are the Chiricahui Mountains. The Sierra Catarina consists of granite, trachyte, porphyry, basalt, and sandstones on its southern extremity, the latter overlaid by basalt and porphyry. Dr. Antisell thinks these sandstones are Devonian, as they underlie the Carboniferous limestones appearing farther to the east in the Sierra Calitro. In the valley of the San Pedro gypseous (cretaceous) rocks underlie the whole depression between the Sierra Catarina and the Sierra Calitro according to the same authority, and these are covered toward the south near the head of the San Pedro by Tertiary gravel conglomerate.

The Calitro Mountains are made up principally of a thick red sandstone formation capped almost throughout by Carboniferous limestone, which in turn is in some places covered by trappean rocks. The next range to the east is the Chiricahui Mountains, which consist of granite overlaid on its flanks by the sandstones and limestone mentioned before. Between the two last-named mountains lies the Playa de los Pimas, an extensive plain, under which the sedimentary strata appearing on the flanks of the ranges dip from both sides. To the northwest of the Chiricahui Mountains rises the Piñaleno Range, of which the former is only a southern extension. It is one of the longest ranges in Arizona, reaching northwest as far as the Rio Verde in the vicinity of Camp McDowell. It is composed of the same materials that compose the Chiricahui Mountains, but reaches a much higher elevation.

North of the Gila and Salt Rivers and west of the Verde, the country looks very much like that immediately west of Tucson. It is an immense plain, which rises to the northeast and north until it reaches the Tonto plateau in the first, and the foot-hills of the Sierra Prieta in the second, direction. The mountains in the vicinity of the Upper Salt River crossing consist of granite, on which rest red sandstone and course conglomerates dipping to the west. The same conglomerates compose the isolated hills to the south of the road from Salt River crossing to Phœnix, while north of that road appear metamorphic slates in the mountains. The plain is here underlain by a thin layer of soft, gray sandstone, probably the same which underlies the basalt overflow mentioned as occurring on the Gila River. In some of the arroyos of this plain a light-colored, soft limestone is visible, underlying the sandstone, very similar to that found at Tucson, which is considered Cretaceous. No fossils were noticed in either of these strata.

On the road from Phœnix to Wickenburg the road leads continually over the mesa without striking any of the "lost mountains" visible on both sides at a distance. The mesa is thickly covered with gravel and detritus from the mountains to the north and northeast, and no rock in place is visible until, about twenty miles south of Wickenburg, the cañon of the Hassyampa is reached. Here are exposed for the whole length of the cañon proper, about fifteen miles, great masses of red and gray sandstone, frequently metamorphosed, and never exhibiting a distinct stratification. In fact, this district has evidently been greatly disturbed, as becomes apparent, on the road from Wickenburg to the Vulture mine, and also on that to La Paz, where the metamorphic slates stand almost vertical.

Directly northwest of Wickenburg, over a level mesa and eighteen miles distant, rise the Martinez or Date Creek Mountains. They are entirely composed of granite and syenite, much crossed by dikes of greenstone-slate and quartz. Following the road from Camp Date Creek to Prescott north, an elevated table-land is crossed, which is entirely covered with scoriæ. It forms the divide between Martinez Creek and the

head-waters of the Santa Maria. Bell's Cañon, a grand cut through vast granitic accumulations, which are frequently crossed by quartzite dikes, is passed in descending in the valleys to the north, which are formed by the creeks running into the Santa Maria. These valleys form beautiful basins, and are covered with a fertile soil. The geology of this region is very interesting, but the party being very weak the immediate vicinity of the trail could not be left on account of the hostile Apache-Mojaves, which swarm in these rocky defiles. The great bulk of the rocks, howevever, is granitic, but metamorphic rocks abound, and in one of the valleys large masses of white sandstone standing isolated in the valley, as left by erosion, were noticed, and opposite, more than one thousand yards distant, the same beds could be observed forming the margin of the valley toward the east and disappearing under the gravel-covered mesa. Vegetation is here improving continually, as the road approaches nearer to the Sierra Prieta, and the whole surface rises very rapidly. In the valleys live-oak, cedar, and a dense chaparral of a small bush-like oak are met with until at the northern base of the Granite Mountain, around which the road leads, the first juniper and pine forests are met with. The western and northern base of the Sierra Prieta, the northwestern terminus of which is Granite Mountain, is flanked by a broad belt of metamorphic slates, which extends west to Williamson's Valley, the slates standing steepest nearest to the main granite ridge. Granite Mountain presents a very imposing spectacle. Rising 3,000 feet above the valley north of it, its rugged sides are covered with immense granite boulders, which are piled up in the most picturesque manner. Its greater part is uncovered by vegetation, but on the northern slope the ravines coming down from the central ridge are thickly covered with large pine to the top. Toward the southeast it runs out into the pine and grass covered Sierra Prieta Range. This range contains all the mining districts in the vicinity of Prescott, and, as I shall refer frequently to its geological structure, I will here dismiss it, saying only that it is made up principally of granitic rocks, which are often cut by dikes of porphyry and greenstone, and flanked by metamorphic slates in every direction. It is over sixty miles long and about thirty-five miles wide. To the east and north of it stretch the Tonto and San Francisco plateaus, separated from it by the Val de Chino and the Agua Frio Valley. The Tonto plateau is reported to be underlain by limestone and sandstone, and as it is only part of the great table-land to the east accidentally cut off from it by the deeply eroded valley of the Verde, the latter is probably formed by the same rocks. Still farther to the east lies the great Mogollon Range, the geology of which is not known. It is the home of the most dangerous portion of the Apaches, and has not yet been explored satisfactorily.

In Northern Arizona the sedimentary strata underlying the extensive plains and table-lands stretching almost unbroken from the Colorado River to New Mexico and north into Utah Territory are better exposed to view than in other portions of the country. The Great Cañon of the Colorado has been eroded over 6,000 feet deep, and exposes all the sedimentary strata of the region down to the underlying granite. Dr. Newberry, in his admirable report on the geology of the route explored by Lieutenant Ives's party, in the latter part of 1857 and spring of 1858, says, in relation to this stupendous cañon, and the country to the east and northeast of it:

"That portion of the central plateau which lies west of the Rocky Mountains varies in elevation from 5,000 to 8,000 feet; the smaller number representing the altitude of its surface where deeply eroded. Its average altitude in the vicinity of our route may be estimated at 6,000 feet.

"Over this plateau the Colorado formerly flowed for at least five hundred miles of its course, but in the lapse of ages its rapid current has cut its bed down through all the sedimentary strata, and several hundred feet into the granite base, on which they rest.

"For three hundred miles the cut edges of the table-lands rise abruptly, often perpendicularly, from the water's edge, forming walls from 3,000 to 6,000 feet in height. This is the Great Cañon of the Colorado, the most magnificent gorge, as well as the grandest geological section, of which we have any knowledge.

Section of the Cañon of the Colorado on the high mesa west of the Little Colorado.

[For heights above the Colorado subtract 1,300 feet from the heights above sea-level.]

Names of strata.	Heights above sea-level.
Upper Carboniferous limestone......	
	6,800 feet.
Cross-stratified sandstones..........	
Red calcareous sandstone, with gypsum.	
	5,600 feet.
Lower Carboniferous (?) limestone...	
	4,600 fe
Limestones, shales, and grits........ Devonian (?)	
Limestones, mud, rocks, and sandstones. Silurian (?)	
Potsdam sandstone..................	
	2,300 feet.
Granite	
	Bed of river 1,300 feet.

"That portion of the table-lands lying between the mouth of the Virgen and the Little Colorado is composed of over 4,000 feet of sedimentary rocks, representing the Silurian, Devonian, and Carboniferous epochs.

"The Silurian and Devonian strata are entirely conformable among themselves and with the Carboniferous rocks. They lie nearly horizontally upon the granite, forming a series of sandstones, limestones, and shales about two thousand feet in thickness. The Carboniferous series consists of over two thousand feet of limestones, sandstones, and gypsum, apparently all marine, and often highly fossiliferous. The upper members of the latter series form the surface of the mesas west of the Little Colorado, upon which the volcanic group of the San Francisco Mountains rests as a base.

"North of the Colorado, near the Mormon town of Parawan, it is said that the true Coal-Measures make their appearance, with workable beds of coal; but south of the river an open sea existed during the entire Carboniferous epoch; the 'mountain limestone' appearing, if at all, in the cañon of the Colorado, and the Coal-Measures being represented here, as is the case farther eastward in New Mexico, by massive beds of limestone, heretofore considered, as I think erroneously, the equivalents of the lower Carboniferous or 'mountain limestone.'"

"The strata composing the plateau bordering the Great and Little Colorados by their dip form an elongated basin, of which the greatest diameter extends from the Mogollon Mountains northwesterly into Utah. The Great Colorado crosses that line nearly at right angles; the course of the Little Colorado being parallel to and locally coincident with it. Near the western margin of the basin some of the older sedimentary strata are seen dipping eastward, resting on the flanks of the mountain chains, which I have described as bounding the plateau in that direction. They here present bold escarpments toward the west, oftener the result of erosion than fracture. They have evidently been elevated by the upheaval of the plutonic rocks upon which they rest; but as they are usually quite unchanged, the igneous rocks could not then have been in a state of fusion, but were themselves the products of anterior eruptions. The oldest Paleozoic rocks are nowhere on our route included in the elevated escarpments to which I have referred; and in the Great Cañon the lower members of the series are seen deposited around and abutting against pinnacles and ridges of granite, which seem to be spurs from the Cerbat or Aztec Mountains. Hence it appears that the mountain chains which bound the plateau on the west existed, at least in embryo, before the dawn of the Paleozoic period, and formed a barrier which, to a great degree, limited the deposition of the Silurian and Devonian strata to the basin-like area lying east of them."

"The same phenomena recur on the other side of the plateau, near the Rio Grande, where the Carboniferous strata are upheaved in many places, and are seen to rest directly upon the granite. The absence of the older rock in both instances is doubtless dependent upon a common cause.

"As has been mentioned, it may well be suspected that some of the strata composing the great plateau recur on the western side of the Black Mountains, beneath the Tertiaries of the synclinal trough of the Colorado basin; and that fused they form some of the porphyries, trachytes, &c., which characterize the mountain chains of that region.

"The Silurian and Devonian sandstones are not recognizable in any of the metamorphosed strata of the Peninsular Sierra, (nor are any of the rocks of the table-lands, unless, perhaps, the Carboniferous limestone,) though they may be represented by the foliated granites and schists. It is quite possible, therefore, that the sediments derived from the erosion of the land during the older Paleozoic periods did not extend so far into the ocean, which bordered it on the west.

"In crossing the table-lands in a direction from southwest to northeast, or nearly in the line of the transvere diameter of the trough formed by the strata, I obtained a section, of which the general features are as follows: Leaving the Lower Colorado, where its bed is less than 500 feet above the sea-level, we crossed three mountain chains, of which the eastern bases are, respectively, many hundred feet higher than the western. When we had passed the third of these ranges, at an elevation of nearly 5,000 feet, we found ourselves on Lower Carboniferous strata, of which the upturned and broken edges form part of the crest of the mountains. They thence extend eastward in a plateau, having a distinct dip in that direction.

"This plateau is locally much broken and covered by floods of lava, which have flowed from the mountains we had passed; and yet, from commanding points of view, we could see that it had a distinct existence, stretching far away as a margin to the mountains, in a northwesterly direction. It is bounded on the east by a wall several hundred feet in height—in many places perpendicular, and generally abrupt—formed by the cut edge of a portion of the Middle Carboniferous series. Having ascended this wall, we found our view again limited on the east by the bold escarpments of the edge of another and much higher mesa, which, with its salient angles, stretched away in magnificent perspective both to the north and south.

"The surface of this mesa has an altitude of nearly 7,000 feet, due in part to a line of

upheaval which traverses it with a trend nearly north-northwest and south-southeast. It is composed of the Upper Carboniferous strata; the later members of that series forming the surface-rock of a broad belt of country extending, from a point southeast of the San Francisco Mountains', northwest across the Colorado into Utah."

"The great volcanic vent of the last-mentioned mountain has been opened up through this mesa, and has doubtless been an important agent in its elevation. Apparently little disruption has been occasioned by it, but the floods of lava and heaps of ashes which have been thrown out of its many flues cover and conceal the underlying sedimentary strata in its vicinity.

"The surface-rock of the high mesa dips rapidly toward the northeast, and forms the western slope of the broad valley of erosion through which the drainage of the northern declivities of the Mogollon and San Francisco Mountains was formerly carried to the Colorado; and of which the surface is now cut by the profound chasms, in the inaccessible depths of which flow Cascade River, and through a part of its course the Little Colorado.

"The opposite side of this valley is formed by a third mesa wall, which at the crossing of the Little Colorado is, with the slope at its base, at least 1,000 feet in height. This mesa is composed of deep-red sandstones, shales, and conglomerates, resting conformably on the Upper Carboniferous limestone, over which is a series of variegated marls, with bands of magnesian limestone. The latter series forms the surface of the mesa for many miles toward the northeast, and has an aggregate thickness of perhaps 1,500 feet.

"The variegated marls and the underlying red standstones are all regarded as Triassic by Mr. Marcou, but the marls exhibit a remarkable lithological identity from top to bottom, and the upper portion contains plants of Jurassic affinities. Without more fossils from these formations it seems to me at least doutbful whether we can draw the lines of classification as sharply as he has done; and it would even be a little surprising if there should ever be found good paleontological evidence for the identification of all the European subdivisions of the Permian, Triassic, Jurassic, and Chalk, of which he claims to have demonstrated the existence in this vicinity."

"Upon the mesa of the variegated marls at the Moquis villages rises still another to the height of 800 or 900 feet, composed of coarse yellow sandstones, green shales, and beds of lignite—a group of strata which has been called Jurassic, but which contain impressions of dicotyledonous leaves, with *Ammonites*, *Gryphaea*, and *Inoceramus* of Cretaceous species. These fossils leave no room for doubt in reference to the age of the strata which contain them, but prove them to be Lower Cretaceous.

"This mesa is, geologically and physically, the highest which we actually passed over on our route west of the Rocky Mountains. Near Fort Defiance its summit has an altitude of nearly 8,000 feet. It should also be said that basin-shaped depressions on this mesa contain fresh-water Tertiary strata, both east and west of the great 'Divide.' At the Moquis villages, the strata forming the table-lands begin to rise toward the east; and near Fort Defiance they plainly show the disturbing influence of the most westerly axis of elevation of the Rocky Mountain system. Farther east, to and beyond the Rio Grande, they are much dislocated, and finally lose their distinctive character in the intricacies of the mountain ranges."

"In the interval between Fort Defiance and the Rio Grande is another great volcanic mountain—Mount Taylor—(San Mateo) which, like that of San Francisco, has burst through the sedimentary strata and poured over them floods of lava, which are as fresh as though ejected but yesterday."

"I have said that the Lower Cretaceous mesa was the highest of the table-lands which we passed over, and yet another must be added to the series before my description of them will be complete.

"On our route across the continent, we passed somewhat south of the center of what we may, perhaps, properly call the basin of the Upper Colorado, and did not, therefore, mount quite to the summit of its geological series. Going north from the Moquis villages, on the Lower Cretaceous mesa, our progress was arrested by a want of water, the surface being everywhere cut by deep cañons, by which it is drained to excess, every rain-drop which falls finding its way immediately into the bottom of these ravines, where it is hurried off to the far deeper cañons of the Colorado and its larger tributaries. Before we turned back, however, we had approached nearly to the base of a wall rising abruptly from the mesa in which we stood, to the height of more than 1,000 feet. This wall was as white as chalk, and reflected the sunlight like a bank of snow. It is evidently the edge of another and higher plateau, and apparently reaches to the Great Colorado, where it caps the 'high mesa,' forming part of the stupendous mural faces, presented toward the south and west, which were distinctly visible when we had receded from them to the distance of a hundred miles."

"What is the character of this upper mesa I had no means of determining at this time, and even now there may be some question about it; but I have scarcely a doubt that it is composed of the Upper Cretaceous strata, the equivalent of the 'white chalk' of Europe."

* On the road from Fort Mojave to Prescott very few sedimentary rocks are exposed to view. The slope from the Colorado River to the Black Mountains is thickly covered with the detritus from the range, and only in the deepest of the dry arroyos running up from the river toward the mountains, beds of coarse conglomerate, and in one instance a thin layer of soft, gray limestone, are seen in the steep sides. The pebbles forming the conglomerate are firmly cemented, and consist of granites, porphyries, trachytes, and quartzite. The Black Mountains exhibit the greatest variety of erupted rocks I have ever met with in a single locality. They are porphyries, trachytes, and basalt, exhibiting the most vivid and varied colors imaginable. On the eastern flank of the range yellowish-gray, soft sandstones occur, which are in places considerably metamorphosed. The valley between this range and the following one to the east, the Cerbat Mountains, is fifteen miles wide, and slopes from either side toward the middle. It is much higher than the sloping ground west of the Black Mountains, and entirely without water. The Cerbat Range consists in its great mass of granite and syenite, but porphyries, trachytes, and trap occur on both flanks. East of it lies the great Hualpai Valley, higher than the foregoing, and some twenty miles wide from east to west, while north and south it stretches from the big bend of the Colorado to the Mojave Range. East of the road leads over the granitic foot-hills of the Aquarius Mountains and over a series of low hills and through cañons, all exhibiting granitic and metamorphic rocks, to the Willows. Still farther east the valley of Fort Rock Springs exhibits immense masses of gray and reddish-brown sandstones, which, in several instances, cap isolated granite cones. They have preserved their horizontal position in all these cases, the valley being evidently one of erosion. These hills present a curious aspect, their sides being gently sloped for two or three hundred feet from the base, and then, when the layers of stratified rock are reached, suddenly exhibiting a cap of from 30 to 60 feet in thickness, with perpendicular edges all around, so that it is difficult to gain access to the top. On the top of several of these hills are the remnants of old Indian towns, the last steps to which could evidently not be ascended except by ladders. To the east of this point the road leads entirely over red and gray sandstones, forming a surface rapidly ascending toward the Aztec Range, which is crossed by the pass of the same name. The cañon leading down to the eastern foot of these mountains exhibits coarse-grained granite capped for twelve miles by a continuous thick layer of brown sandstone dipping to the northeast. From this point to Prescott the road leads southeast through Williamson's Valley, a beautiful agricultural district, exhibiting no stratified rocks, and then over the upturned edges of the metamorphic rocks forming the foot-hills northwest of the Sierra Prieta to Granite Mountain and the valley of Granite Creek, where Prescott is located.

The geology of the valley of the Great Colorado, from Fort Mojave, may be indicated in a few words. The sedimentary strata of the entire valley consist of Quaternary and Tertiary (?) gravels and conglomerates, varied in a few localities by a layer of white, infusorial earth, as in the side cañon southwest of the Chemehuevis Valley. The bottom-lands consist of calcareous sands and clays, the former predominating. A great number of mountain chains skirt both banks of the stream, sometimes coming quite up to it and crossing it, and in a few cases running

* The remainder of this chapter is left in the first person, as Mr. Eilers transmitted it to me, and in his own words.—R. W. R.

parallel to it. These mountains are composed of granites, syenites, porphyries, trachytes, greenstones, basalt, and metamorphic slates, and most of them contain a vast number of mineral veins. They are quite destitute of vegetation and very rugged in outline, presenting the most fantastic shapes and imparting to the entire landscape a somber, dreary hue.

The country intervening between the Gila route on the south and the Mohave route on the north is crossed by the road from La Paz to Wickenburg. This road, one hundred and twenty-eight miles long, leads over a continually rising plain, which is only in one place, at the so-called "Granite Wash," broken by an upheaval of coarse-grained granite. The mesa is covered throughout with the detritus from the mountain chains visible to the north and northeast, and exhibits no rocks in place until the cañons and ravines leading to the Hassyampa above Wickenburg are reached. Here the same metamorphic slates and quartzites, with occasional porphyries and basalts, are exposed, which are mentioned before as occurring to the south and southwest of Wickenburg.

I have thus endeavored to give a general outline of the geology of the known portions of Arizona Territory, well aware that it will require very extended and protracted surveys to definitely settle its details and their relations to each other over so vast an area. The latter is especially difficult from the absence of fossils in most of the exposed sedimentary strata, and their extraordinary frequent dislocation and metamorphosis by intruded igneous rocks. These exist in the Territory in greater abundance and variety and I think of more different ages than in most countries of which the geological structure is now known, and it is therefore not surprising that they are so extensively and generally accompanied and crossed by veins containing the ores of nearly all the useful metals.

YAVAPAI COUNTY.

The mining districts of the Sierra Prieta.—The Sierra Prieta has been repeatedly mentioned in the preceding pages. The characteristics of this important range differ entirely from those of the mountain chains to the south, southwest, and west of it. While the latter rise suddenly out of the level plains and mesas like rugged islands out of an ocean, surrounded on all sides, as it were, by the level sea of sand and gravel up to the very foot of their craggy sides, the main granitic axis of the Sierra Prieta is on both the northeast and southwest slopes flanked by a multitude of low hills stretching away from the central line of the upheaval for many miles, and joining around its northern as well as its southern terminus. On both these extremities, however, the decline in altitude is much more sudden than along the sides of the range, thus forming on the northwest Granite Mountain, a grand mass of granite, visible for many miles in all directions, and on the southeast Bradshaw Mountain an equally precipitous but not quite as rocky elevation. The foot-hills on both sides of the chain consist of metamorphic slates, which are highly inclined and frequently even vertical. On the northwest, north, and northeast these slates course parallel to the main granite spine, but toward the southeast they impinge on it more and more, and part of them even form the east side of the Bradshaw Mountain, and cross its southeastern slope.

In the Sierra Prieta and its foot-hills are located some of the most important mining districts of Arizona. They assume especially higher importance because in these districts the items of wood and water are

abundantly provided for—a recommendation which cannot be applied to most of the other mining districts of Arizona. A number of creeks head in the Sierra Prieta, the most important of which are the forks of the Hassyampa, Lynx, Big Bug, Turkey, Walnut, and Granite Creeks. They flow into the Hassyampa, Agua Frio, and Verde or San Francisco Rivers, and in ordinary seasons contain sufficient water the year around to run stamp-mills. For extensive placer-mining, however, they furnish enough water for about half of the year only.

The whole main range of the Sierra Prieta is covered with timber, and the northeast slope is especially thickly covered with a most beautiful pine forest. The valleys and mountain-sides are everywhere covered with a thick growth of bunch-grasses, including two kinds of grama; and the magnificent pines, the meadow-like surface here and there varied by irregular piles of granitic boulders, and the deep and narrow valleys of the main creeks, impress upon the region the character of a park laid out by nature in the grandest and most picturesque style.

Hassyampa district is situated on the southwest flank of the Sierra Prieta, on the two forks of the Hassyampa River and Maple Gulch. The district was first visited and organized by prospectors in the spring of 1864, originally to work the placers only, but subsequently a large number of quartz veins were discovered and located. At the present time few of the quartz leads in this district are worked, but the placers along the several affluents of the Hassyampa and those on the main stream furnish employment for quite a number of miners. The placer-gold is distributed everywhere in the district—even the heads of the smallest side-valleys and the slightest depressions on the top of the mountains containing it. The earth and gravel containing the gold are nowhere deep, hardly ever more than 6 feet, and the whole detritus is evidently of local origin, and furnished by the decomposition of the underlying granitic and metamorphic rocks with their veins. The narrowness of the valleys—often only 12 or 15 feet wide—has prevented placer-mining on a large scale, and the danger from Indians for a small number of whites collected at any one point has also deterred many from following this branch of mining. According to the best information I could obtain, these placers pay from $3 to $6 per hand per day—a yield which, in California, would be considered quite satisfactory; and, in isolated cases, as much as $200 per hand has been obtained. The placers on the main creeks, where water is abundant for the rocker and sluice-boxes, have, to a great extent, been worked over; but at the heads of the valleys this is not the case. Nor will these higher placers ever be available for profitable working, except on a small scale during winter, after the melting of heavy snows, simply because no supply of water can be brought to them, unless the climatic conditions of the country be entirely changed. The drought during last year was very severe, and hindered washing for gold greatly, but the next season it is hoped will make up for this, and several long flumes are now under construction. The number of quartz veins in this district, as indeed in every one in the Sierra Prieta, is astonishingly large. Only a few of them, however, have been prospected in depth, and all of these revealed the unpleasant fact that the decomposed quartz carrying free gold reaches only down to a small depth—generally 30 to 60 feet—where water is encountered and the undecomposed sulphurets of iron, copper, lead, and zinc. Although these are in nearly all cases gold-bearing, they have so far not been available as a gold ore, for the lack of a cheap process to beneficiate them. Most of the veins in this district occur in either syenite, greenstone, or metamorphic slates. Although, as mentioned before,

only a few of these veins are at present worked, I will enumerate some of them in the following as an illustration of the character of the lodes in this district:

The Chase vein is situated on a long hill on the southeast bank of the Upper Hassyampa, about ten miles nearly due south from Prescott, with which it is connected by a rough mountain road. The country rock here is syenite and greenstone. The vein is 2½ to 5 feet wide, strikes northeast and southwest, and dips about 75° northwest. It is opened by two shafts on top of the ridge, from one of which a level is run northeast toward the other, at a depth of 20 feet from the surface. The two shafts are about 50 feet apart, but the level has not been cut through between the two. The vein is also opened by a tunnel over 200 feet in length, running in on the vein in a southwest direction, from the mouth of a ravine close to the Hassyampa. In the shafts, quartz slightly colored yellow by ochreous products of decomposition is met with, and in the tunnel, striking in on the vein about 400 feet lower, the white quartz is filled with the sulphuret of iron, often crystallized, and constituting about 3 per cent. of the ore. In the ten-stamp mill erected on the Hassyampa, less than half a mile from the vein, the decomposed ore is reported to have yielded from $7 to $20 per ton, while the concentrated sulphurets assayed from $35 to $130 per ton. The above yield of the decomposed ore is not sufficient to pay for working at this place, and the experiments made for working the sulphurets proved a failure. The mill was driven by steam-power, but the engine is now removed. There are two batteries of five revolving iron stamps each, and copper-plates. The concentration of the iron pyrites was imperfectly carried on in a Hendy concentrator, but their roasting in a curiously-shaped revolving wrought-iron cylinder, which was heated from the outside, and the amalgamation by some mysterious electrical process, in a wooden tub, were the most amusing part of the process. It was a total failure. This property lies in the midst of a splendid pine forest, as do all the following ones in the district.

The Lion is a large vein in metamorphic slate on Maple Gulch, an affluent of the Hassyampa, three-quarters of a mile above their confluence, and eleven miles from Prescott. It runs along the south side of the ridge dividing the Hassyampa and a fork of Maple Gulch, and can be plainly traced for over a mile. It is not opened, except by prospecting holes, where it shows a width of 6 to 7 feet. The ore is a porous quartz, filled with hydrated oxide of iron, and prospects well, especially a gossan-like red layer of about 2 feet in width in the middle of the vein. This ore has yielded in an arrastra $28 per ton, but the vein, being owned by poor men, without means, is not worked now. Higher up the hill this same vein carries decomposed copper ores, red oxide, and green and blue carbonates, which show gold when prospected.

The Chloride and Morning Star are two claims on the same vein on the opposite banks of the Hassyampa, below the foregoing and a short distance below Smith's water-wheel and arrastra. The vein stands nearly vertical between greenstone on one side and greenstone-slate on the other, strikes northeast and southwest, and is 4 to 5 feet wide. The country-rock just mentioned is often very close-grained, and passes into basalt, carrying much olivine. This mineral is very frequently met with in all the erupted rocks of Arizona, not alone disseminated through their mass in crystals, but still more frequently filling small seams running in all directions. The vein contains yellow sulphuret of copper in the quartz almost from the very surface, and it is in one part of the vein quite solid. Even those pieces of quartz which have a decomposed

appearance show sulphurets of iron and copper when broken. A quantity of this ore worked at the Chase Mill is reported to have yielded $32 per ton in free gold, and assays of the concentrated sulphurets, I am assured, have yielded over $500 to the ton. But if this be so, I cannot see why the vein is not worked, for the facilities for working it cheaply by tunnels are uncommonly good, and the distance of the vein from the Chase Mill is hardly more than one mile.

The Astor vein, six hundred yards above Davis's cabin and arrastra, higher up on the Hassyampa than the foregoing, stands in greenstone. It is only one foot wide, strikes northeast and southwest, and dips steeply southeast. The ore is a highly ferruginous, porous quartz, a few tons of which, worked in an arrastra, have yielded from $50 to $70 per ton.

The Brandon, a short distance above the foregoing, is 18 inches wide, and strikes northeast and southwest, as exposed in a small shaft about 7 feet deep. The ore is a ferruginous honeycomb quartz in which free gold is visible. It is worked to a small extent.

The Senator is a large quartz vein about a mile above Davis's cabin, crossing a ridge on the left bank of the Hassyampa. It strikes northeast and southwest, and dips steeply northwest. In a short tunnel driven in on the course of the vein near the creek it is 6 feet wide, and contains dense white quartz filled already a few feet from the surface with undecomposed iron pyrites and some zinc-blende. These minerals are very evenly distributed through the quartz, and constitute about 5 per cent. of the vein-matter. I noticed many druses in this vein which are covered with beautiful quartz crystals. The pyrites are also frequently crystallized. There is no free gold visible, but the pyrites are reported to assay $40 per ton. The Senator is a contact-vein between granite and greenstone.

The President and Victoria are two veins carrying both very porous brown quartz. They are situated at the extreme head of Maple Gulch, and lie both in metamorphic slates, striking like these northeast and southwest, and dipping southeast. The former is opened in prospect-holes 3 feet wide, the latter from 2 to 5 feet. A few tons from the first, worked in an arrastra, yielded $40 per ton.

The Sterling mine has become quite famous, as much on account of the richness of the sulphurets it contains as from the repeated failures in working them. It was discovered in 1866, and is located six miles south of Prescott and one mile from the Hassyampa River. It has changed hands several times, and is at present owned by a San Francisco company. It occurs in greenstone and metamorphic slates, parallel to which it strikes northeast and southwest, and dips with them to the southeast. There are very large croppings of brown-streaked quartz on the surface, which have yielded in the mill belonging to the company from $15 to $20 per ton. The vein is opened by an incline 5 by 6 feet and 118 feet deep. The largest body of ore was encountered from the surface to a depth of 53 feet, where the quartz was 16 feet wide and filled with iron and copper sulphurets, the former largely predominating. This chimney continued of the same size for 100 feet along the strike of the vein as far as explored, but in depth it gave out below the 53-foot level, the vein-material down to the bottom of the shaft being slate, with many quartz seams and lumps, and full of pyrites. Part of the chimney above the 53-foot level is stoped out, and piles of this ore are still lying on the dump and at the mill. This sulphuret-bearing quartz yielded, in a lot of 100 tons, $15 per ton in free gold. The sulphurets were concentrated and worked imperfectly by chlorina-

tion, and $600 more were obtained from the lot. The sulphurets constitute about 10 per cent. of the ore. The iron pyrites yielded, by assay, from $60 to $600 per ton, while the copper sulphurets never assayed higher than $30 per ton. This is remarkable, as it is contrary to all experience in Colorado, New Mexico, and at other localities in Arizona, the copper pyrites proving generally the richest in gold of the two.

The stamp-mill belonging to this mine is erected about three-quarters of a mile east of the mine, and one-half mile from the Hassyampa, in a very unfortunate locality, on account of the scarcity of water. This might easily have been avoided by locating it on the Hassyampa River, where there is plenty of water all the year round. It has ten iron stamps arrayed in two batteries and long copper plates. From these and an inclined plane the pulp runs into two Hungerford concentrators and blankets. The concentration of the sulphurets is imperfect. Chlorination works, consisting of a long reverberatory roasting furnace of a capacity of four tons per day, and the necessary vessels for the development of chlorine gas, as well as wooden tanks for the reception of the roasted ore, are also erected at this mill, but they have never been in perfect working order. The mine and mill are now both idle.

The country in the vicinity of the Upper Hassyampa is considered very dangerous on account of roving bands of Apaches, and, indeed, only a few days before my visit to the district an old miner had been killed and brutally mutilated close to the Astor lode. This man, I was told, was the last one of a party of twenty, who had come to the country fifteen years ago, and all of whom had been killed at different times.

Turkey Creek district.—In passing over the divide between the headwaters of the Hassyampa and those of Turkey Ceek, the trail leads over alternating zones of quartzite and granite, greenstone and greenstone-porphyry, the latter in some cases assuming a slaty structure. In one of the last-mentioned zones occur on the Turkey Creek side of the divide several veins which carry galena. One of these is the Cyclop, a small vein, about 10 inches wide, containing coarsely crystalline, solid galena. It strikes northeast and southwest with the slates, and dips 80° southeast. It is only opened slightly in a few prospect-holes.

The Homestake is another large galena vein, lower down in the ravine, southeast from the foregoing. It is 4 feet wide, strikes northeast and southwest, dips 90° southeast, and carries a heavy outcrop of porous, hydrated oxide of iron on top. This is colored in some instances by an efflorescence of carbonate of copper. There is a shaft sunk on it which, at the time of my visit, was full of water. Pieces of lead ore on the dump attest that the ore reached by it is galena, slightly mixed with copper pyrites.

The Goodwin occurs about one mile and a half lower down than the foregoing, on a series of low hills, on the left bank of Turkey Creek, and one-half mile from that stream. It lies in a bed of yellowish-white metamorphic clay slates, parallel to their strike, which is like that of all the metamorphic slates of the northeast flank of the Sierra Prieta, northeast and southwest. The vein, although narrow, has been traced for over a mile in length, and is opened by a shaft 50 feet deep, and three or four open cuts along its strike. The width in these places varies from 6 to 10 inches, and the character of the ore is throughout the same. It is quartz, containing green and blue carbonates of copper, chloride of silver, and lower down fahl-ore. This ore assays over $300 per ton, and this amount per ton has been extracted from a shipment of about one thousand pounds, which was sent to San Francisco to be

tested. In the above-mentioned shaft the vein dips for the first 25 feet 90° northwest, but becomes here suddenly much flatter. This mine, although rich, cannot be worked to a profit at present, on account of its small size. It could not reliably supply a mill with ore, even if opened by an extensive system of shafts and tunnels. But whenever the cost of transportation to and from this country is reduced to within reasonable bounds, the ore of this vein, worked in connection with the Galena, mentioned before, in blast furnaces, will become very valuable. Timber for such a purpose, both pine and live-oak, is abundant in the neighborhood of this part of Turkey Creek.

The Capital is a silver vein, a few miles from the Goodwin, and carries ores very similar to those just described. It is also a narrow vein and undeveloped.

A number of gold veins have been located and opened in this district, and a splendid stamp-mill was erected by the Bully Bueno Company, but none of the mines have proved successful. The claim on which the most work has been done is the Bully Bueno, which is a deposit quite as singular as its barbarous name. It is one of the many illustrations, so frequently met with in the West, of "how mining ought *not* to be carried on." A splendid twenty-stamp mill was built by this company, an eastern association, before the mine was in the least developed, and when this was finally accomplished, it was only to prove that the mine was not worth it. The mining works are located on two hills, separated by a deep gulch, about one and a half miles south of Turkey Creek. The deposit is an irregular body of quartz, filled with large patches and threads of hornblende. It occurs in metamorphic slates running northeast and southwest, and dipping steeply to the northwest, and the quartz bodies strike and dip with them. These constitute no vein, but are lenticular masses, entirely independent of and overlapping each other, as plainly shown in the shafts and tunnels. These are well planned and located, and had the mineral matter proved sufficiently rich to pay, they could have supplied a twenty-stamp mill with ore.

Near the top of the southern hill a cut along the vein 300 feet long, and from 20 to 30 feet deep, has been made, and the hornblendic quartz, here 3½ to 4 feet wide, has been entirely removed. Lower down on the hillside is a tunnel 60 feet long, in which a winze is sunk to the depth of 40 feet. Still lower down, and about 100 feet above the bottom of the ravine, is another tunnel, 230 feet long. In this tunnel are two shafts; the one near its mouth is in the hanging wall of the deposit, and strikes it at a depth of 35 feet; the other is a short distance in the tunnel, and is sunk on an incline of 85°. In this tunnel the lenticular shape of the deposits is well shown. Where the second shaft is sunk, the body of ore followed in the tunnel from the surface thins out and finally ceases, and another one is met with in a crosscut of 8 feet in length in the hanging wall. Where fullest developed these bodies are 7 feet wide. Hornblende is found in great quantity in the quartz throughout, but not a trace of pyrites. It is claimed that at one point at the surface, where the hornblende was entirely decomposed, imparting a rusty color to the quartz, this ore yielded over $100 per ton in arrastras, and that a number of tons of this rich ore were so worked, whereupon the property was sold to the company which now owns it. It is certain, however, that the great bulk of the ore does not contain more than $6 per ton. Large piles of this lie about the mouths of the several shafts and tunnels and at the foot of the chute, which is built in a substantial manner from the lower tunnel to the bottom of the ravine, where wagons were to receive the ore. On the opposite hill occur two

zones of the same nature as the one just described, one of which lies very nearly in line with the works on the other side, while the other is parallel to the first and west of it. The eastern one has been opened by two inclines. In the upper one, which is 15 feet deep, a body of quartz and hornblende shows right at the top, but it pinches out 4 feet from the surface. The remainder of the shaft is sunk in slate. The lower incline is sunk 40 feet deep upon a large mass of quartz and hornblende, at least 8 feet wide. At this point, it is claimed, the ore was found at the surface which proved so rich in arrastras. The mill on Turkey Creek was evidently a substantial structure, and contained twenty stamps, run by a steam-engine. It has been burnt to the ground by Indians during the last spring, and the rusty and bent remnants of the stamps and other machinery, entirely worthless in this place, are all that remains. The distance from this place to Prescott, by a very good trail, is twenty-two miles; by wagon road, about forty.

A number of other gold veins have been opened in this district, and on a few of them considerable work has been done; but none were successful, and their shafts and tunnels are now impassable.

Bradshaw district.—Bradshaw Mountain forms the southeastern extremity of the Sierra Prieta. It is connected with the main range by a series of low hills occupying a depression between it and Mount Union. But while the trend of the main ridge of the Sierra Prieta is northwest and southeast, that of the two high parallel ridges, forming the Bradshaw, is nearly at right angles to the former, being a little north of east and south of west. These two ridges are connected by a lower spur, which, leaving the most northern of the two main ridges in about its middle, joins the southern one not very far from its southwest terminus. About one-half of the northern mountain is composed of granite, the remainder of metamorphic slates, greenstone, and porphyry. The bulk of the southern ridge and the spur connecting the two are nearly entirely composed of metamorphic rocks, greenstone, and porphyries, only the southwestern end of the ridge exhibiting granitic rocks.

Both the main ridges of the Bradshaw are over 9,000 feet above the level of the sea, and rise above the low hills, forming the connecting link with the main Sierra Prieta, at least 2,000 feet. The ascent is very steep on all sides, so that on the trail leading up the mountain side the rider must dismount. Magnificent gorges come down from the range on the northwest and southeast; and between the two ridges on the east side of the connecting spur exists a broad valley, through which the main streams, Poland and Arrastra Creeks, hasten toward the "Black Cañon," formed by the close approach of the two main ridges toward the east. In this valley, which, although it has an outlet, is called the "Basin" by the miners, on account of its shape as seen from the top of the northern ridge, occur some of the richest veins in the district on the contact between the greenstone and syenite and in the latter.

The large pine, which disappears on the connecting hills between the main Sierra and the Bradshaw, again appears on the latter, and covers it thickly from top to bottom; and grass, which, however, covers the whole region, grows most luxuriantly and plentifully on its very top.

The portions of the mountain underlain by granite and syenite are, throughout, covered with several feet of earth, while those underlain by slates, porphyry, and greenstone, show less earthy matter and a large amount of boulders and slate detritus.

The Bradshaw district in its present boundaries is a new district. One of that name was formed several years ago nearer to, and in

the "Black Cañon," and several very good veins, which yielded rich gold-ores, were located and worked; but the mines had to be given up on account of the Apaches, who were very numerous in the "Black Cañon." The Ballenciana especially is a large vein, and produced ores yielding in arrastras $100 per ton; it was at one time reported sold to an eastern company. The present "Bradshaw district" is located on top of the more northern of the two main ridges. The discovery of the lodes of this district created quite an excitement during the spring and summer of last year, and some of the veins have really produced very handsome yields. By far the most of them, however, are only locations, opened in some cases by cross-cuts and shallow shafts. All the veins in the district have a northeast and southwest strike, and dip either to northwest or to southeast.

The Bradshaw vein was discovered in March, 1870. It is located on the west side of a deep ravine, running from the northern main ridge of the mountain toward the north, strikes northeast and southwest, and dips steeply northwest. It is opened by several cuts along its course, one of which is about 20 feet long and 8 feet deep. The vein is 20 inches wide, lies between greenstone and porphyry, and contains a yellowish-brown decomposed quartz, with carbonate of lead and arseniate of iron. This ore prospects well in free gold, but has not been tested in large quantity. The location takes 1,000 feet of the vein.

The Bradshaw first extension southwest is 800 feet long, and the open cut on it exhibits the same characteristics of the vein as the foregoing.

The Mountain Springs is located on the western slope of the same spur as the foregoing, but farther to the south. It lies between hornblende slate on the hanging-wall and syenite on the foot-wall, strikes northeast and southwest, and dips with the slates about 80° southeast for the first 16 feet, where the dip changes to the opposite direction. The shaft on it is 20 feet deep, and exhibits 2½ feet of ore in its bottom, while it was blind at the surface. The ore is brown porous quartz, with carbonate of lead and much argillaceous matter. It contains spots of arseniate of iron, like the foregoing. The location is 1,000 feet long on the vein, and is owned by Captain Shoup, Wm. Cole, A. Austin, and Mr. Dougherty. The ore prospects well. The Black Chief and Louisiana are two small veins containing similar ore, and lie three hundred yards farther south; they are parallel to the Mountain Springs.

The Richmond is opened on top of the northern main ridge of the Bradshaw; strikes like the others, and dips 85° southeast. It occurs in greenstone, and the shaft, sunk on it to the depth of 22 feet, exhibits a vein 2½ feet wide of brown honeycomb quartz, containing throughout much hydrated oxide of iron, arseniate of iron, and carbonate of lead, with face gold. On both sides of this quartz vein occurs white clay in bands and patches. The length of the location is 1,000 feet. It is owned by A. Austin and others.

The Aztec lies farther east than the foregoing, on the same ridge, in greenstone, containing much olivine in large patches. It is opened by a small shaft, which shows the vein to be 15 inches wide at the bottom, while at the top it was blind. The character of the ore is entirely that of the foregoing. The location is 1,000 feet long, and owned by A. Austin and others. Both the last-named veins run toward the northeast down into a ravine, where they can be opened by tunnels 200 feet lower down than the discovery shafts.

The Del Pasco is the vein which has caused most of the excitement raised in regard to the Bradshaw district. It is situated on the east

slope of one of the spurs running down from the main ridge toward the north and east of the foregoing veins. It is a contact-vein, its foot-wall being a light drab porphyry, while its hanging wall is greenstone slate. Like the others, it strikes northeast and southwest, and dips southeast. At the time of my visit, (October, 1870,) an open cut about one hundred and fifty yards in length had been made, and the ore taken out for a depth of from 8 to 15 feet. The deepest shaft was only 20 feet deep. These openings showed a vein of from 18 inches to 2 feet, consisting of pretty much the same minerals as those enumerated above, only the vein matter was softer and contained more argillaceous matter and yellow arseniate of iron. The latter is most concentrated in a streak 6 inches wide running along in the vein, sometimes in the middle and oftener on either side. This is the richest in gold. The ore had been worked so far in two arrastras erected close to the vein on a little stream in French's Gulch, and the first lot of 6½ tons had yielded 112 ounces of gold, selling for $17 per ounce, making a little over $1,900. The second lot of 20 tons, according to the owners, and of 27 tons, according to some outsiders, had given a product of 116½ ounces, or $1,980. Even assuming that the last version is the true one, the yield of $73 per ton must be considered an unusually good one. At the time of my visit preparations were being made to transport to the mine a four-stamp mill, to be run by steam, an undertaking which, on account of the great steepness of the mountain, was by no means easy to accomplish. I have since received advices that the mill has been successfully erected, and that the vein is now 4 feet wide at the deepest point reached.

The mining work at the time of my visit was badly planned and executed, the open cuts being in many places filled in again by waste material, and no tendency being visible to open the mine in depth and secure reserves.

The original location is 1,000 feet long, and is owned by the Jackson Brothers of Prescott, Chas. Taylor, Jas. Fine, and McCracken. Several extensions on it are located, but not opened. There are two small veins running parallel to the Del Pasco, 4 and 6 inches wide, on the same slope below it. They are also contact-veins between porphyry and slate, the dikes of the former recurring here very frequently. The ore is of the same character as that of the Del Pasco, but not as rich in gold. A great number of similar veins are located and slightly prospected in this district. They are all on the same main ridge and its northern spurs. One fact is quite remarkable in connection with the veins of this district: they all carry, besides the gold, more or less arseniate of iron and carbonate of lead, and the gangue is soft. This is of course not injurious to amalgamation as long as the ores remain decomposed; but small pieces of undecomposed galena and arsenical pyrites, occurring even at the slight depth of from 20 to 25 feet in some of the veins, though surrounded by decomposed matter, lead me to suspect that decomposition will be found not to extend far down, and that then the same trouble will here be encountered that prevents the working of the Hassyampa and Lynx Creek mines in depth. But should the galena be found solid enough to permit smelting, its connection with the gold and pyrites can of course only prove beneficial for the prospects of the district.

Pine Grove district.—This district must not be confounded with another of the same name, which was several years ago organized on "Pine Flat," on the western foot of the Bradshaw Mountain, and which is for the present abandoned, though some of its veins, notably the Minnehaha, are reported as rich. The present Pine Grove district is

located in "the basin" referred to above, between the two main ridges of the Bradshaw Mountain, in the low spur of the two, and at least 1,800 feet lower than the veins spoken of under the head of "Bradshaw district." The descent from the first or north ridge of the Bradshaw to this district is exceedingly steep and precipitous, as the trail runs now, and this side of the northern main ridge is almost entirely composed of metamorphic slates. The timber disappears on this declivity, and in its stead the mountain is covered by thick chaparral. Lower down in the valley the pine forest is met with again, covering the whole basin and the side and top of the second main ridge opposite.

The locations in this district were made later than those in the Bradshaw, and the work done here amounts really only to prospecting. Two arrastras are, however, built, and have been run on surface-ore.

The New Era is a vein running along a north and south spur of the northern main ridge of the Bradshaw Mountain, and is at least 1,600 feet lower than the Del Pasco. It is a curious vein, the vein-matter being apparently nothing but a decomposed white feldspathic material, with many quartz segregations, occupying a rent in the syenitic granite. It runs a little east of north, and dips 50° southwest, between smooth and well-defined walls. There are streaks of light, yellow arseniate of iron in the vein, and the quartz is often crystallized. The fissure is exposed in a shaft 15 feet deep, and has a very uniform width of about 6 feet. This strange vein-matter prospects quite well throughout, as I satisfied myself by repeated tests, and in spots shows free gold, which, however, always occurs in the quartz particles and the yellow arseniate of iron. Tests of average vein-matter prospected $20 to $25 per ton; and I was informed that assays had revealed the presence of more silver than could be contained in the gold, though the gold itself, to judge from its light color, contains much silver. As the ore resembles very much that from the upper levels of the Comstock lode, which afterward turned out to be preëminently a silver lode, it will be interesting to watch the future developments on this vein.

The Dexter is a vein running at right angles to the foregoing, and contains a similar ore. It is very slightly opened.

The Belfast is another vein running northeast and southwest, and dipping northwest. It is 2 feet wide, and contains ore somewhat similar to that of the New Era. It is, however, more quartzy and somewhat colored by hydrated oxide of iron and arseniate of iron. The small shaft on this vein has produced some beautiful specimens of wire-gold.

The Osinippa, a vein containing ore very much like the foregoing, has the same strike and dip, and is 1½ feet wide. The quartz is porous and brown, and contains arseniate of iron. In the 10-foot shaft the vein has selvages on both walls.

All the foregoing veins lie in syenitic granite. The Burro and Shelton are two adjoining claims on the same vein, both 1,800 feet long. The vein occurs in granite, is 2½ feet wide, strikes northeast and southwest, and dips steeply northwest. The ore is a porous quartz, containing much brown hydrated oxide of iron. The vein is opened by an open cut 50 feet long. Three tons of the ore taken from here have yielded $38 per ton in the arrastra erected close to the vein on Arrastra Creek. But the tailings from this run are so rich that a good color can be obtained from them with a horn spoon. The ore contains also some arseniate of iron, but is much harder than that of the veins before spoken of.

The Young Vulture is a quartz vein in granite higher up the creek from the last-named, and some 300 feet above the level of the valley. The surface-quartz is brown and porous, and shows arseniate of iron

and copper stains. It pans well, but a few feet down in the prospect hole galena and copper pyrites make their appearance. The vein has large cropping in spots along its course, but is generally not over 18 inches wide. Its dip and strike are the same as that of the foregoing.

The Hagan, Chattahoochee, Benton, California, Espinosa, and a hundred others are newly discovered veins in the district, but none of them have as yet been developed.

The veins of this district, it will be noticed, differ from those of the Bradshaw district in their country-rock and in the vein-matter in so far as it contains, with a single exception, no lead-ores. The ore is also more quartzy and harder, and will probably always have to be worked by stamp-mill process, for which the facilities in the district are satisfactory. The two districts last under consideration have, singularly enough, never been infested with Apaches since their organization, although the "Black Cañon" and the Agua Frio Valley, where they are found at all times, are not far distant. Between thirty and forty miners and prospectors were employed in the district at the time of my visit.

I have since been informed that placers have lately been discovered in the "basin." If so, they cannot be of large extent, as the valleys are all narrow, and without bottoms on either side.

Walker district.—This district is named after the pioneer of the Prescott region, Joseph Walker, who, with a party of prospectors, in 1863, followed the Hassyampa River into the Sierra Priéta, and crossed over into the valley of Lynx Creek, where they found rich placers. These diggings have been worked more or less ever since, and support quite a number of miners at the present time. Most of the diggings on the upper creek have, however, been worked over, but lower down, where the valley widens out considerably, much ground remains to be worked. The difficulty in this lower part of the creek is the insufficiency of the water supply, the size of the stream being greatly diminished by the excessive evaporation going on during most of the year, where the valley leaves the main mountain and enters the lower foot-hills, which are not covered by timber. The material of which these hills are composed, the metamorphic slates, cause also the loss of much water by sinking.

During the last year the great drought has hindered placer mining very much, and none of the four hydraulic claims along the creek have been in operation, while the shallow placers have been worked to some extent during about four months.

A great many quartz veins carrying gold have been located, and more or less opened in this district, but few were being worked when I visited the district, and both mills which have been erected here were idle. The district is one of the most dangerous in regard to Indians, who in the woods and behind the rocks find excellent opportunities of watching and waiting for a good chance to either steal the stock or kill the miners themselves with impunity. Both of these performances take place only too often, and as long as this state of affairs lasts, outside capital will be slow to invest here, and to extend a helping hand to the poor miner. Another cause of the stagnation of mining here is the occurrence of sulphurets at inconsiderable depth in the veins, which cannot be profitably worked with the present high cost of transportation by any well known process.

The Flag is a quartz vein at the head of Lynx Creek in quartzite. It strikes northeast and southwest, and dips 85° southeast. The ore is porous, and of brown color, and has a width of 14 inches. The vein is opened by two open cuts in opposite hill-sides, and was worked during last summer

by Mr. C. Y. Shelton, who beneficiated the ore in his arrastra lower down the creek. It yields handsomely, but is not near as rich as the ore of the Vernon, also owned by the same gentleman, who preferred to turn his attention to that vein.

The Plymouth, a vein in the granite west of and close to the Eureka mill, is opened by a little prospecting shaft 10 feet deep. It strikes northeast and southwest, and dips 95° northwest. There are two bodies of ore, separated by a horse 2 feet wide, exposed in the shaft; the ore on the foot-wall is 18 inches wide, and that on the hanging wall 5 inches. The ore is iron-stained, porous quartz, which prospects very well, but an actual working test has never been made. The walls are smooth and well defined. The Vernon is parallel to the foregoing, but dips flatter. It is a narrow but very rich vein. The width of pay-ore is in most places only 8 inches, but it bulges out sometimes to two feet. It is opened along its strike for 600 feet or more, and ore is taken out to a depth of from 6 to 20 feet. A tunnel 125 feet long is driven in on the vein from a ravine near the northeast end of the claim, which cannot have in any place more than 50 feet of stoping-ground above it. The last run of ore from this mine produced in Mr. Shelton's arrastra from twelve tons a little less than $2,000. The gold is worth $17 per ounce.

The Box Elder is located on a hill northwest of and parallel to the one on which the two last-mentioned veins are located. It strikes parallel to those just described, but stands vertical. It is opened for 500 feet by an open cut, and here entirely stripped of decomposed ore. Its width here is 3 to 4 feet, but in the bottom of a shaft 80 feet deep, near the northeast end of the claim, the vein has widened out to 6 feet. The decomposed ore has yielded from $25 to $40 per ton, but already at a depth of 18 feet sulphurets of iron, copper, zinc, and lead made their appearance. One portion of the vein 4 inches wide, consists of solid galena, and at least 20 inches of the vein consists of sulphurets sufficiently concentrated to need no dressing for smelting. At least 50 per cent. of the vein are sulphurets, and in a trial during last summer these yielded by roasting and subsequent amalgamation $35 per ton, although the roasting was done imperfectly. To Mr. Tiernan, who conducted the test, I am indebted for this information.

About 50 feet southwest of the 80-foot shaft, the vein narrows down to a few inches, and the crevice is occupied by a mixture of solid galena and copper pyrites, which assay $40 per ton in silver, and contain only a trace of gold. Only 25 feet further toward the southwest, the vein opens out again to 1½ feet, and carries porous quartz, which is, however, also poor in gold. Further on the contents in gold increase until, at the open cut, the quartz yields as above stated. The original location is 1,800 feet in length, but the vein has been traced across an affluent of Lynx Creek, and on the opposite hill, where it is 2 feet wide, and shows sulphurets already 4 feet from the surface. This vein can be worked to some extent by tunnels on its course, which would bring in 200 feet of stoping-ground on one hill and 100 on the other.

The Monitor is a vein between the Box Elder and Vernon, and parallel to both, but is opened further to the northeast. An open cut 30 feet long exposes a vein of rather solid-looking quartz, with brown spots of iron ore, which are rich in free gold. The gold is of fine size, like that of all the Lynx Creek veins, with the exception of that from the Tie-Tic and Accidental.

The Pine Mountain, an irregular vein in granite, with the same general strike as the foregoing, contains quartz with coarse, cubical iron

pyrites, and much zinc-blende. It has been tested for 400 feet in length, and has not yielded more than $10 to $12 per ton.

The Tie Tie runs nearer north and south than the remainder of the veins of this district, and finally turns entirely northwest at right angles to the common strike, tying together, as the miners say, the other veins, whence its name. In the first-mentioned portion it dips east 85° and afterward northeast. It is open on the southwest end of the location by an open cut 50 feet long and 25 deep, and shows an irregular crevice, with many horses in it. In the shaft, however, the vein is solid, and, at a depth of 18 feet, 4 feet wide. On the northeast end of the location it is opened by another well-timbered open cut, 75 feet long and 20 feet deep, and here the vein-matter varies in width from 4 to 8 feet; but there are also several horses in the crevice. No sulphurets have yet been struck. The decomposed ore contains arseniate of iron, and has yielded in spots $100 per ton in arrastras. The last run, however, of ore from the northeast end of the location, yielded only $10 per ton in the Eureka mill. This mill is, however, very imperfect, and it is more than likely that much of the gold was lost.

The Twin, below the Tie-Tie, on the same hill, has the usual strike of the veins in the vicinity, northeast and southwest, and dips southeast. It is opened by two small shafts, which show the quartz 2 to 4 feet thick. It has been worked in arrastras, and is said to have yielded $40 per ton.

The Henry Clay, opened in a small ravine, is a contact vein between granite and greenstone. It is 2 feet thick, and the porous quartz shows galena and carbonate of lead. It contains gold and a considerable amount of silver.

The Billy Pointer Ledge is, considering all the circumstances connected with it, by far the best vein in the district, and perhaps the most valuable in all the Prescott region. It is lower down on Lynx Creek than all the foregoing, and close to the stream. It lies in a greenstone dike, not far from its contact with the granite on the east, strikes northwest and southeast, and dips very steeply to the southeast. The main vein is, on an average, 4 feet 8 inches wide, but it has side-veins or branches on both sides, which sometimes run along with it 8 to 16 feet off on either side, and sometimes join it. These are often 3 feet, and never less than 2 feet wide. The lead was discovered and located by Wm. Pointer, familiarly known as "Uncle Billy Pointer," an old Colorado pioneer, who came to this country in 1863, after having made and lost a fortune in one of the Gilpin County gold leads, which to this day has a good reputation. Uncle Billy owns 400 feet on the lead, and ever since 1866 he has worked this property entirely alone for a living. He is a fine specimen of a Western pioneer, one of the men who have always kept in advance of the railroads, and who don't feel well unless separated from civilization by hundreds of miles of Indian country. He is now quite old and white-headed, but he still does all his work without any aid whatever. He sinks his shafts and mines his ore, leaving his faithful dog at the mouth of the shaft to watch for Indians, and when he has dug out a bucket-full he ascends the ladder and winds it up himself. In the same manner he takes it alone to his arrastra, which is close by, and grinds his own ore by water-power, the 18-foot wheel of which was built by his own hands. He has sunk two shafts, one 34, the other 22 feet deep, and three prospect holes of 10 to 12 feet in depth on the main vein and its branches. In all of them a splendid body of porous brown quartz is exposed. A horse of greenstone met in one of the shafts cut out again in a few feet. None of the ore worked so far has yielded less

than $30, nor more than $42 per ton, and between these two figures the whole contents of the vein vary in different places. In the deepest shaft sulphurets of iron, copper, zinc, and lead were struck at a depth of 30 feet, and in the bottom of the same shaft they are 7 feet wide and very solid, so that they would immediately furnish material for smelting. In one of the side-veins to the south of the main lead occurs a 6-inch layer of solid galena. In 1866, the first year of his working the vein, Uncle Billy took out $300; in 1867, 1868, and 1869, $2,000; and in 1870, $1,200. Considering the circumstances and the surrounding difficulties, the most prominent of which are the Indian troubles and the distance from which Mr. Pointer has to get his supplies, (for he can neither plant anything nor raise stock,) this yield is very satisfactory. There is sufficient water in Lynx Creek at this point to run the arrastras continually for six months by water-power; and Mr. Pointer told me that in one year he had run for nine months. For a ten-stamp mill, driven by steam-power, there is an abundance of water throughout the year. I am, however, inclined to believe that the ore of this lead will in future have to be treated by smelting; and whenever freights will become sufficiently low to and from these parts so that the base metals, lead and copper, will pay for their transportation, this vein will be a splendid basis for a prosperous mining enterprise. There are several extensions located on this lead, one of 200 feet to the north, and one of 800, the McClellan, to the south. Both of these have been worked to some extent, and the value of the ore is the same as of that in the original.

The Accidental is another very good vein. It is located east of all the others, on a high hill, on the opposite bank of Lynx Creek. It stands in quartzite slate near its contact with gneissoid granite, and runs with it in the usual direction, but dips 85° northwest. This lead is 3 feet wide, and has produced some of the richest ore in the district. The quartz is porous, and shows free gold to the naked eye; that from the middle open cut, which is 30 feet long and 20 feet deep, and from the 30-foot tunnel continuing in on the same level, has yielded as high as $100 and $150 gold per ton in different runs. Besides these, there is a shaft 75 feet deep 200 feet higher up on the hillside, which was intended to strike the tunnel ultimately. In its bottom the vein is 3½ feet wide, and shows sulphurets of iron and copper in abundance. Above the shaft there are several open cuts from 10 to 15 feet deep and 600 feet long. Another shaft, 60 feet deep, is southeast of the one just mentioned; it has also struck sulphuret. Fifty feet below the first-named tunnel, and at the bed of the ravine, a second drift, which is, singularly enough, started in the foot-wall, is driven in 135 feet and cuts the vein near its end. The ores encountered are solid sulphurets of iron and copper, which would yield good material for smelting into matte. There occur beautiful crystals of carbonate of lead and galena in this part of the vein. This tunnel brings in about 140 feet of stoping-ground at the second shaft. The vein is at present not worked, as I understand, because some of the owners are not willing to or cannot furnish their portion of a working capital to erect proper reduction works for the sulphurets.

The Eureka is a very irregular contact-vein, between granite and greenstone, on which an incline of 90 feet in depth was sunk. The quartz contains coarsely crystallized iron pyrites and little gold.

The Deadwood is parallel to the former in granite, and carries the same poor ore. It is 8 feet wide, has the usual strike, the same as the foregoing, and dips southeast. High expectations were at one time entertained in regard to these veins, but they have not been realized.

The Eureka Mill, on upper Lynx Creek, and close to all these veins,

has ten stamps, driven by steam-power, and no apparatus to catch the gold besides the copper plates in the batteries. Formerly aprons, covered with copper plates, were arranged in step-like manner outside of the discharges from the mortars, and imperfect concentrating machinery was erected below; but these are now removed. There is also a small, caved-in reverberatory and an arrastra connected with the mill. It has been running for a few months during the summer, but was idle during my visit.

The Thunderbolt Mill is about two miles lower down on Lynx Creek. It consists of a thunderbolt crusher and four arrastras run by steam, and was idle when visited by me. The whole is well built, and ought to reach good results with the ores of the district.

Big Bug and Goodwin districts.—These districts are situated about six miles east of the last described, and twenty miles from Prescott by trail, while by wagon-road the distance is much greater. It is difficult at present to draw the line between the two, but both are located on the hills along the banks of the Big Bug Creek. Some placers have formerly been worked along this stream and its branches, but I am not aware that any mining of that kind has been carried on in the district during last year.

Many veins occur in the neighborhood, and a number of them have been opened and worked to a considerable extent. At the time of my visit, however, only one mine was in successful operation. The country is considered dangerous on account of the Apaches, whose trails lead across it, and suffers from a scarcity of water, except in the immediate vicinity of the creeks.

The Big Bug vein occurs in syenite, less than one mile from the mill of the same name. It is a two to four foot vein, running northeast and southwest, and dipping steep to the northwest. The quartz is full of patches of hornblende, which at the surface is decomposed, imparting a brown rusty color to the vein. Yellow-sulphuret of copper occurs in it in irregular spots along its course, and these portions contain gold. There is a shaft on it 50 feet deep, and some small levels have been run from it. The gold extracted from this ore is reported to have been much coarser than that from the following mine; it is not in operation at present:

The Eugenia (original location) is not in operation at present; but the extension furnishes the ore for the Big Bug Mill. The vein is worked by Messrs. Hitchcock and Gray, the latter of whom is the superintendent at the works. I am indebted to this gentleman for much valuable assistance in regard to the examination of his own mine and mill, as well as that of the other veins in the district. The Eugenia is located on the high hill between the two forks of the Big Bug Creek, and the shafts and cuts at present worked are not more than one and one-half miles above the mill. They are all on the top of the hill, the highest at a point 350 to 400 feet above the spot where the right fork of the creek crosses the vein. This occurs in a belt of metamorphic slates, which runs northeast and southwest, between syenite on the southeast and a dike of greenstone on the northwest. The latter is very close to the vein, and sometimes sends offshoots into it, forming hard horses. The lead strikes with the stratification of the slates, and has often a very slight dip to the southeast, while in places it appears vertical. The original location is opened by a tunnel running in from the left fork of Big Bug Creek, but not worked now. I could not enter this tunnel; but the ore on the dump shows much sulphuret in the quartz, which is said to assay well in gold, and the quartz has, besides, yielded $13 per ton in free gold,

At present this portion of the vein is not worked. The mining works of the extension to the southwest are principally on top of the hill, and they are sufficiently advanced to give a good idea of the character of the vein. It is opened and prospected by actual working tests for a length of over 2,000 feet, along much of which the surface ore has been stripped by open cuts down to the sulphurets. Besides these there is a shaft on the top of the ridge 65 feet deep, in the bottom of which very solid, fine-grained sulphurets of iron, without a trace of other sulphurets, were met with. About 100 feet to the southwest of this shaft another one, 53 feet deep, has been sunk, which also struck sulphurets; 56 feet further on another shaft is sunk to a depth of 46 feet, and, 120 feet still further, one of 40 feet. Some of these shafts are connected by galleries; at other points the connection is not yet established. Below the last-mentioned shaft, nearer to the extreme southwest end of the claim, several prospecting holes and a shaft 30 feet in depth are located. Northeast of the upper shaft are several more prospecting holes and shafts, one of them 50 feet deep and sunk to the sulphurets. In all these openings the vein is found of a uniform character, but differs somewhat in size. While at the top it is generally narrow and split up into several seams, it uniformly becomes wider and more solid toward the bottom of the shafts. These seams vary from 6 inches to 2 feet in width, and the average size of the vein may be put down at 2½ feet; still, the existence of other similar seams outside of this fissure is evident by the croppings to its right and left. It is curious that the vein was in many places quite unproductive in the first 6 to 13 feet from the surface, while at that depth well-paying ore was always reached.

The general experience has been that the narrower the pay-streak the richer the ore. A great deal of ore has been taken from these openings. It is very soft, consisting of a loose quartz, colored highly by hydrated oxide of iron, and associated with much argillaceous and talcose matter The horses of slate, which often occur in the vein, are also to some extent gold-bearing. They are, however, not near as rich as the brown vein material, but they cannot be well separated from it, and are to a great extent permitted to go through the mill. The ore is so soft and easily mined that, if the vein happens to be wide in his front, a man can easily take out two tons per day; the general average, however, is a little over one ton per day to the hand. Where the sulphuret of iron has been struck it is found to constitute from 20 to 30 per cent. of the ore; and in the bottom of one of the shafts is a streak one foot wide, which is almost nothing but pyrites. Nothing definite is as yet known in regard to the average value of these sulphurets, but assays of unconcentrated samples have gone from $10 upward, so that the concentrated material will probably contain about $40. No attempt has, however, as yet been made to work these ores, and the mill runs altogether on free-gold ores. From the present mining works an excellent wagon-road leads down the hill to the mill, but should the sulphurets prove sufficiently valuable to encourage the erection of the proper reduction works, these ought to be located at the point where the vein crosses the right fork of Big Bug Creek. There is a splendid mill-site at this place, and the water supply never fails. The vein could then be worked from a tunnel run in on the vein, which would secure, if driven in from the level of the creek at the point under discussion, about 300 feet of stoping ground above. The cost of transporting the ore to the mill could thus be reduced to almost nothing.

At present ten men and a foreman are employed in the mine, and these supply the mill with ore; but little can be done with this force to

secure reserves. Mining and transporting the ore to the mill costs now $4 50 per ton, and the milling, including superintendence, &c., costs about as much more. A detailed statement of the cost of labor and material will be found further on.

The Big Bug Mill has ten stamps, and copper plates inside and outside the mortars. Those outside are arranged step-like, nearest to the discharge; from these the pulp runs over an inclined plane, about 14 feet long, and also covered with plates. Outside of the building the pulp runs first into vats, where the heavier portion settles and the rest goes into the creek. There is also an arrastra in the mill, in which part of the tailings caught in the vats are ground over, and a little more gold is thus extracted. The whole is run by steam The arrangement of the mill does not suit the ore. While it contains from $20 to $25 per ton in gold, only a little over one-half of that amount, as I was informed, about $14 on an average, is saved. The gold is very fine, and mostly in the form of thin scales. This, of course, floats easily; and, to make things worse, the talcose and argillaceous matter in the ore still more prevents the contact of the gold with the copper plates. It has been attempted to remedy this somewhat by using a great amount of water in the batteries, and a little more gold has thus actually been obtained; but at the same time this rush must necessarily also carry off much gold, and by panning the tailings this can easily be seen to be so. The proper way to work the ore would be to use little water in the batteries, and amalgamate in pans; but the owners hesitate to buy pans now, and prefer to work on in the present manner until they are enabled to erect sulphuret reduction works and remove the mill to the point mentioned above.

The mill employs four men and a foreman, who is also a machinist, and reduces from 11 to 13 tons in twenty-four hours. The softness of the ore would permit the reduction of a much greater amount of ore in that time, but this rate has been found to be the most economical for yield.

Cost of labor and material at Big Bug.—Miners, per day, $2 50, and board; mill-men, including engineers, $2 50 per day, and board; board, per day, per hand, $1; foreman, per month, $100; lumber, per mille, $55; wood, per cord, $3; wrought iron, per pound, 16 to 18 cents; cast iron, 12 to 14 cents; quicksilver, per pound, 75 to 80 cents; corn, per pound, 7 cents. It costs about $1 per day to feed a horse or mule in the stable; and this must be done, though the pasturage in the whole district is unsurpassed, on account of the Apaches. The daily expenses of the mill and mine are from $90 to $100, and it is entirely due to the very economical management of Mr. L. C. Gray, that the enterprise, in spite of the surrounding difficulties, is a financial success. The mill has, as far as I am informed, only stopped twice during last year, both times a short while only, and on account of the extraordinary drought.

The Galena is a large contact vein between talc-slate and syenite, about two miles northwest of the mill. It strikes northeast and southwest, and dips steeply southeast. There are three shafts sunk on this vein, of, respectively, 105, 60, and 50 feet, all located within a distance of 300 feet. The ore at the surface is an iron-stained quartz, 350 tons of which yielded $16 50 per ton. The ore in depth is quartz, containing a mixture of sulphuret of iron, copper, zinc, and lead. The sulphurets of 75 tons of this ore were concentrated to 14 tons, and I am informed that these assayed $580 per ton. This is certainly an extraordinarily high yield, and at that rate this 5-foot vein must be considered

a fortune. Nevertheless, it is not worked now, for want of proper apparatus to beneficiate the sulphurets.

The Pine-Tree is a large quartz vein, in syenite and slate, west of the foregoing. The croppings are from 2 to 10 feet wide, but it is so little opened that it is impossible to form an opinion as to its value.

The Dividend vein seems to be a continuation of the Galena. It is in line with it; lies, like it, between syenite and talc, and dips southeast. The quartz, however, looks white, and rather dense and barren, though it contains a good many iron-stained seams. There are two shafts on it, one 30 and the other 40 feet deep. No sulphurets have as yet been struck in them. Sixty tons of the surface ore were worked four years ago, which yielded \$20 per ton, not sufficient, in those days, to pay for working, especially as all the ore has to be blasted. There is also a tunnel driven in on this vein from the valley below, which is 50 feet in, and struck sulphurets of iron and lead. The vein is here only 1½ feet wide.

The ore from all these veins, and the following ones, would have to be transported to Big Bug Creek, to work it, and this, together with the fact that it would have to be blasted, leaves it doubtful whether it would pay for working at the present time.

The Ticonderoga is a noted vein, the ore being unusually rich. The vein strikes like all others, dips southeast, and is 1½ to 4 feet wide. It occurs in syenite, and has a thin casing of talc-slate on the hanging wall. There is an open cut and a tunnel on it. In the latter the vein was lost, but it was found again in a shaft, sunk from the tunnel floor to a depth of 35 feet. The quartz remaining in sight in the tunnel is brown and porous, and shows fine free gold in places. A four-stamp mill, with a thunderbolt crusher, four arrastras, and a Hendy concentrator, all driven by steam, was erected at the mouth of the tunnel, in a most unfortunate locality, as there is a sufficiency of water for only one month in the year. The ore worked in it is reported to have yielded \$100 per ton. The mine and mill have changed owners lately, and Mr. Herbert Bowers, the present owner, intends to remove the mill to the Agua Frio, four miles distant, and to resume work on the vein.

The Independence is probably the northeast continuation of the last-described vein. It shows quartz croppings 7 feet wide, on which two shafts of, respectively, 10 and 30 feet deep, have been sunk. In the latter, the quartz is divided by a horse of slate into two parts, of 1½ and 4 feet in width. Most of the quartz is dense and barren-looking, but there occur porous spots here and there. Two and a half tons of the ore worked in an arrastra yielded \$55 per ton.

The Chaparral and Oversight are two veins, both slightly opened, in the neighborhood. The last-named was discovered last summer, and two small shafts have been sunk on it, which show 7 feet of quartz. This vein dips much flatter than the other lodes of the district, not over 56°, and lies entirely in metamorphic slate. The ore contains slight copper stains, and prospects well in gold. It is intended to transport it to the Agua Frio, two and a half miles distant, for reduction. A sample sent to San Francisco for assay yielded \$100 per ton.

The Agua Frio, in this neighborhood, is quite a considerable stream, and all accounts agree that in the driest season it will furnish 130 inches of water. It is intended to drive the machinery to be erected on this stream by a water-wheel.

There are several other mining districts in the vicinity of Prescott, which I could not visit; but those described are the representative ones,

and convey an accurate idea of the character of the mineral deposits of this region.

Silver Mountain is a district fifteen miles southeast from the Bradshaw Mountain, which contains some large veins carrying silver ores, none of which are now worked.

Pine Grove, an old district at the foot of the Bradshaw, contains gold veins, which are not worked now.

The old *Bradshaw district*, in Black Cañon, has already been mentioned in the preceding pages.

The *Leihy copper mines*, between Prescott and Skull Valley, contain rich decomposed copper ores and native copper, but are not worked.

The United States mine, a galena vein carrying silver, is in the same neighborhood. There were three shafts sunk on this vein, of, respectively, 40, 60, and 15 feet in depth. The vein dips 45° southeast, and strikes northeast and southwest. The ores found in it are carbonates of lead and galena. The bullion smelted from this ore assays, according to a certificate of the San Francisco assaying and refining works, $114 28 in silver.

Walnut Grove district, northeast of Wickenburg and southwest of the Bradshaw Mountain, on the Hassyampa, contains some rich veins, at least one of which is now worked profitably. This is the Rainbow, a vein reported to be 4 feet wide, and containing ore which yields $100 per ton. There is an incline of 20 feet in depth on it, and a tunnel is being run toward it, which at last accounts was in 80 feet, but had not reached the vein. The ore is worked in arrastras. No sulphates have as yet been found in the openings. Wood and water are abundant in this district.

The placers at Antelope Hill, south of the Bradshaw Mountain, which caused such an excitement in 1864, and have been worked more or less ever since, were last year worked by only a few Mexicans. The gravel has to be "dry-washed," as it is on top of the hill and no water near it. It is undoubtedly the product of local disintegration, and the gold must come from veins on the spot. This assertion, in view of its former great abundance, may seem strange to those who are not aware of the immense erosion and denudation which at a remote period, and under climatic conditions entirely different from the present, must have taken place all over the Territory of Arizona, but it is difficult to explain this singular occurrence otherwise. Lately, public and private advices from the Prescott region are filled with glowing accounts of the discovery of a remarkably rich silver lode, a short distance southwest of the Bradshaw Mountain, and the equanimity of the good citizens of Prescott seems to be considerably disturbed by the excitement resultant from it. The vein is called the Tiger, is said to be 4 feet wide and extraordinarily rich, the ore assaying as high as $1,500 per ton. No details in regard to the discovery are known at the date of this writing, but all accounts agree as to the richness of the lead.

Martinez district.—The mines of this district, more familiarly known as the Date Creek mines, were discovered early in the spring of 1870. They are situated twenty miles northwest of Wickenburg, in a southerly spur of the Martinez Mountains. The surrounding mesas are an excellent grazing country, but wood is scarce, small mesquite and palo verde, with some scrub-oak and a few cottonwoods on the creek, being the only trees visible as far as the eye can reach. Martinez Creek, northeast of the mines, furnishes water enough for arrastra and stamp-mill purposes. The Apache Mojaves, who roam over this country, were peaceable at the time of my visit.

The country rock of the district is a coarse granite, in which occasional dikes of greenstone and greenstone slate occur. It is full of veins, some of which contain porous, iron-stained quartz, likely to contain gold, but the majority of the leads are composed of dense white quartz. Very little work is done in the district. It is confined in almost all cases to the sinking of a few prospect-holes on the leads, which, according to the district laws, are sufficient to hold the claims for one year. The excitement which broke out in the neighborhood upon the discovery of the district was principally due to the Mayflower, which showed much free gold in the croppings.

The Mayflower location, 2,000 feet long, is owned by Mr. Harris and others, who discovered it in May, 1870. The granite has a finer grain in the vicinity of the vein, which is situated on the side of a mountain spur about 125 feet above the mesa to the south of it. The vein strikes northwest and southeast, and dips about 45° northeast. This strike, it will be noticed, is exactly at right angles to that of all the lodes in the different districts of the Sierra Prieta. The croppings of this lode are in most places porous and promising, and its width in the cross-cut is a little over 4 feet. A little shaft, about 8 feet deep, was sunk in it, which struck hard, white, barren-looking quartz. Still, there is coarse gold visible in this in some spots. Four tons of the croppings were worked in an arrastra erected on Martinez Creek, about two miles distant, and yielded $105 per ton. Some 60 or 70 tons of the ore were transported over a new road, fifteen miles long, to Wickenburg, and worked in the Hinton mill, and the result of this crushing, I am told, was very unsatisfactory, the amalgam containing much iron and very little gold. One reason of this is undoubtedly the fact that the mill was run for the first time, after having been idle for a long time.

The Queen of Palmyra is a lode parallel and below the Mayflower. Specimens of the ore assay $52 in gold, and show carbonates of copper.

The Martinez is located on the northeast slope of the same hill on which the foregoing are located. It is 4 to 6 feet wide, and a shaft 10 feet deep is sunk on it. The rock prospects well, but shows sulphurets of iron already at this small depth. There is a spring within two hundred yards of this vein.

The Date Creek or Gnome is two hundred yards west of the former, on the same slope, but higher up. It is 3 to 4 feet wide, and carries similar ore to that of the Martinez.

Real del Monte, one mile west of Mayflower, and only one-half mile from Martinez Creek. It is 15 to 18 inches wide, has slate casings, and carries the best-looking ore in the district, showing much free gold. Two specimens from this vein have assayed, the one $252, the other over $600 per ton.

The Montezuma is half way between Camp Date Creek and Colomber's ranch, in granite. It strikes east and west, and dips steeply to the north. It is a large vein, being 8 feet wide, and the quartz is dense and iron-stained on the surface. There is little work done on it.

The Cornucopia. This large vein is situated three miles south-southwest from Camp Date Creek, near a spring, and in a depression of the ridge, between two high peaks. The croppings protrude 8 to 10 feet above the surface, and form a high wall for twelve to fifteen hundred feet. The quartz is dense and contains sulphurets at the very top. Specimens are reported to assay $42 per ton.

The Buena Vista is a vein 2 feet wide, situated one mile southwest of Camp Date Creek; it strikes northeast and southwest, and dips northwest. The quartz is very porous, and very much iron-stained, and assays

of specimens from this lode have yielded as high as $250. There are no developments on the vein.

The Zuñi, a lately discovered silver vein, six miles northwest of Camp Date Creek, is 2 to 3 feet wide, and carries galena, copper pyrites, and fahlore. The ore assays very high, but there is no work done on the vein yet. This vein is not in Martinez district proper, and was discovered, on a scout for Indians, by a military detachment from the post.

The developments of the Date Creek mines are not sufficient to justify an opinion as to their value. At the same time, it is but fair to say that, to within a month or two, it was impossible for a white man to stay in these mountains, the Indians being then intensely hostile. At the time of my visit seven miners were employed on the Mayflower, and several Mexican pack-trains and wagons were engaged transporting ore to Wickenburg for reduction.

Wickenburg district.—This is by far the most important district in Arizona at the present time, and yields alone about one-half of the yearly gold product of the Territory. It is at the same time a single mine which supplies all this gold, in spite of the most serious drawbacks which, outside of the mine itself, can embarrass a mining enterprise. This mine is the Vulture. The Vulture lode was discovered by Henry Wickenburg, a German, who, with a few companions, prospected in this neighborhood in the fall of 1863. The distance from the vein to the Hassyampa is fourteen miles, and there is no water in its vicinity. The party had been without water for some time, and were well nigh discouraged; so that when this monstrous hill of quartz was discovered the weary prospectors did not even care to go to the trouble of examining it. Mr. Wickenburg, however, did so, and posted his notice at once. The actual discoverer of this valuable property has not had much benefit of his good fortune. Like nine-tenths of our mining pioneers, whose energy brought to the world's notice the hidden treasures of what was then a wilderness, Mr. Wickenburg lives now, if not in needy circumstances, at least provided with less than an average share of worldly goods, near the town of Wickenburg, where he owns a small farm.

The Vulture is located fourteen miles southwest of Wickenburg and of Vulture City, the place where the company's reduction works have been erected. The country for a great distance in all directions around the mine is entirely underlain by quartzites, which are evidently all metamorphosed sandstones. They are mostly very highly colored by oxide of iron, dense, hard, and exhibit little trace of stratification in most localities, while at others it is quite plain, the rocks running northeast and southwest. The immediate zone, however, in which the Vulture lode lies is one of talc-slate, which is four hundred yards wide. The body or bodies of gold quartz lie in about the middle of this belt, and strike and dip parallel to the stratification of the slates, which runs a little north of west, and dips north-northeast 45°. In the lowest levels, however, the veins show a tendency to assume a steeper dip.

The croppings of this remarkable lode rise 80 feet above the level of the mesa, at their foot, and form quite a hill for themselves. The hill on which they occur is 450 feet long on the line of the strike of the vein, and 250 feet across its base. Eighty-five feet in width of this is vein-matter, which lies between well-defined walls, showing clay selvedges in places. These become more distinct in depth, when, at the lowest level, a seam of grayish-black clay, 10 inches thick, overlies the vein. These croppings at the surface show gold everywhere; but there are here four distinct quartz-layers which are richer than the remainder, and the ore

from which is now transported to the company's mill, while the rest, which does not bear the high cost of transportation, is laid aside and piled up at the mine for future use. Of this latter ore there are outside of and in sight in the mine at least 160,000 tons; all of which may be safely called twelve-dollar ore. The richer portions mentioned above have the following widths:

	Feet.
The "Red" or "Front vein"	12
The "Middle vein"	6
The "Blue vein"	9
The "Black vein"	5
Total width of rich ore in the croppings	32

These are not mined, but quarried, all above the level of the mouth of the main shaft being taken down together. Even in the talc-slate horses, between the pay-quartz, is gold, as I have satisfied myself by panning when on the spot. This slate is in many places full of square cavities, partly filled with soft brown hydrated oxide of iron, evidently the result of decomposition of crystalized iron pyrites. But there are also numerous small quartz-seams, from an inch to one foot thick, both in the horses and even outside of what are considered the walls of the lode, at the surface, which contain much gold.

A short distance below the level of the mesa there is suddenly a fault in the vein, or rather in the four splits of the vein, as appearing on top; the part above this line being thrown a considerable distance to the south. The "Black vein" runs into the "Blue vein" before this fault is reached; the "Middle vein" loses itself in the "Front vein," between the 70-foot and 165-foot levels, and the "Blue" and "Front veins" approach close to, and finally run into each other a short distance below the 165-foot level. Here the dip of the vein becomes somewhat steeper, the distance between the walls is diminished, and at the 240-foot level the thickness of the vein is 47 feet. The richest ore lies here nearest to the walls.

The reserves in the upper levels are not as rich as the ore taken out heretofore, still an immense amount of fifteen-dollar ore may be taken from them with some assorting. The vein contracts at the eastern line of the claim now worked, and widens out towards the western line; but here the quartz becomes nearly barren.

The Vulture Company owns 500 feet on the original location, but the present mining works are altogether located within 300 feet on the course of the vein. When the present company took hold of the mine it was in a very bad condition, not even the most common rules of mining engineering having been followed in the planning and execution of the work, and only during the last year or two have the works under ground been systematized and laid out with a view to permanent prosecution of the work. Whims are still employed to raise the ore from the lower levels, and the absence of water has rendered the introduction of pumps unnecessary. At the time of my visit the lowest level reached was 245 feet, and the ore was here as free from sulphurets as it had been near the surface; *i. e.*, it contained from 1 to 1½ per cent. The ore sent to the mill is not permitted to contain less than $25 per ton, and much of it yields over $30. A great deal of this is taken from the quarry on top, but the richest ore has lately been struck in the lowest levels, where assays of ore from the incline below the 240-foot level yield over $90 per ton. Mr. Peter Taylor, the mining captain, writes in a late

communication: "Since you were here, I drove the lower incline and struck a fine body of ore, which belongs to the 'Front vein;' it is very much decomposed, and much easier extracted than the quartz above. I have drifted east on the body, and am now in 50 feet, at which point there is still fine ore in the face of the drift. The streak of this rich pay-ore lies between two perpendicular seams, and is 13 feet wide. I have extracted and shipped to the mill unassorted 400 tons, which have given fine results. I am now sinking a winze on this body, and it is still improving." Some very showy specimens have been extracted from the body referred to in the above, and the latest developments in the winze show extraordinary richness of the quartz throughout.

Seventy tons of quartz are forwarded daily by mule teams from the mine to the mill, fourteen miles, at a cost of $8 per ton by contract. The Hassyampa is the only stream in the vicinity, and not even a spring is nearer to the mine. An enormous cost of transportation is thus forced unto the enterprise, and the bulk of the ore is at present entirely useless. It is proposed, therefore, to bring the water from the Hassyampa to the mill in pipes. There are no natural difficulties in the way of accomplishing this, but it will require a heavy outlay for the dam and the pipes, and will probably not cost less than $180,000. Still, even at this figure, the saving on transportation alone will repay the outlay in a little over a year, not to mention the vastly-increased amount of quartz which will then be available. It is also proposed to enlarge the forty-stamp mill, after its removal to the mine by the addition of sixty stamps, all of which can undoubtedly be easily supplied with ore. The mill at Vulture City, one mile above the town of Wickenburg on the Hassyampa River, contains an eighty-horse-power engine, a Blake's crusher, 40 revolving stamps of 650 pounds each, copper plates and blankets, and eight of Hendy's concentrators. It is in excellent running order, and crushes from 66 to 70 tons daily, stopping only during the day-time on Sundays to clean up. The stamps have 10 inches lift, and the best results are claimed to be obtained by running them at the rate of 65 strokes per minute. The concentrators dress the sulphurets, of which there are not more than 1½ per cent., up to 15 per cent. only, and these are separately preserved outside of the mill for future beneficiation, there being no apparatus on hand at present to work them. Different assays at various times of the tailings concentrated to the percentage in sulphurets mentioned have yielded from $25 to $91, while entirely pure sulphurets assay $350 per ton. The sluice-tailings assay $5 per ton, and are also thrown up below the mill to be worked over in the future. There are between 75,000 and 80,000 tons of tailings thus saved, at least 6,000 tons of which contain partly concentrated sulphurets. Four assays of average samples of these sulphurets concentrated during two succeeding weeks gave $75 and $78 per ton for the first week, and $42 50 and $45 50 for the next. Besides the large mill building, Mr. B. Sexton, the efficient manager of the company, has erected a large office, storehouse, assay-office, containing retort and melting furnaces, boarding-house, sleeping apartments, and the necessary outbuildings, all of adobe and with shingle roofs, at Vulture City, and a store, office, dwelling-house, and other necessary buildings at the mine, all substantially constructed of stone. The company also cultivate a garden of 12 acres in the Hassyampa bottom, a short distance below the mill, in which they raise all the vegetables required in their large boarding-house. The cooks are Chinese, the only celestials which the writer met with in Arizona, except one in Arizona City, who keeps the only hotel in that town.

One hundred and two men were employed at the mine, and twenty-

four at the mill, one-half of the latter wheeling quartz. Twelve to thirteen more are employed, some of whom work on the ranch, and the remainder are mechanics. The common wages are $70 per month, and board is deducted at $1 per day. Wood is scarce in the vicinity, and costs about $8 delivered at the mill.

The cost for working one ton of ore in the fall of 1870, taken on an average during one month, was, according to data kindly furnished by the superintendent, as follows:

	Per ton.
For mining	$4 12
For milling	2 81
For hauling	8 00
Total expense	14 93

About 2,000 feet of extension are taken up on the Vulture lode, 800 of which are owned by the Vulture Company. None of these extension claims were, however, worked in 1870. Lately the papers report that parties have commenced working one of the claims, and that the ore is to be crushed in the Hinton ten-stamp mill at Wickenburg.

The road between Wickenburg and the Vulture mine was formerly very dangerous on account of the Apaches. Many attacks were made by them not many years ago on men and teams, and generally the whites were the losers in life and property. Lately, however, the Indians have kept quiet in this region, except in the immediate vicinity of Wickenburg, where they have stolen horses and cattle several times during last year.

Unexplored region.—Yavapai is by far the largest county in Arizona, and not more than one-quarter of its area has been explored. That part of the remainder which is known to contain the precious metals, the country south of the Mogollon range, the Sierra Blanca and Sierra Pinaleño, have been occasionally traveled over by strong military parties, and a few posts have lately been established there. One or two prospecting parties have also ventured into this country, but were compelled soon to retrace their steps, the Apaches, whose stronghold this region is, harassing and annoying them continually. No permanent foothold has been gained by the whites upon this country, but those who have returned from there report gold placers northeast of the Four Peaks, situated in the Sierra Pinaleño, forty miles from Camp McDowell. They also report that the country is well watered and wooded throughout, from the Tonto Basin to the Mogollon range and east of there. In the Piñal Mountains enormous silver lodes are claimed to have been discovered by a party who went to that country from McDowell in November, 1870, and specimens of the ore were shown to me at Wickenburg. The ore was fahlore and copper-silver glance, and if the reported size of the vein, 50 feet, is not greatly exaggerated, this region will probably soon be invaded by large numbers of miners. The most important discovery, however, especially in regard to the thirty-second parallel railroad, is that of coal in the southern foothills of the Sierra Blanca. General Stoneman's party, who had traveled through that country, brought specimens of this coal to Tucson, where some of the members of the party showed them to me. It is a highly bituminous coal and seems to be free from iron pyrites, if examined closely under the glass. The bed is reported to be of workable size, and, according to all accounts, must occur in the true coal measures.

Beds of lignite are known to exist in the more recent strata of the northern and northeastern plateau, but the quality of the coal and the size of the seams appear to give little satisfaction.

MOJAVE COUNTY.

This county lies along the Colorado River, between Bill Williams's Fork on the south and a line drawn east from the Roaring Rapids on the north, its eastern boundary being longitude 113° 20′. Several mining districts have formerly been formed in this county, but in none of them has any work been carried on for several years, except in the old Sacramento, now Hualpai or Wallapi district, which was reorganized on the conclusion of peace with the Hualpai Indians during the summer of 1870.

The Wauba Yuma district.—Located in the northern part of the Aquarius range, this district is about fifty-five miles from the Colorado River. It contains much pine, cedar, and some walnut, and a tolerable supply of water. Many locations were taken up here before the breaking out of the southern portion of the Hualpai tribe of Indians, and several shafts were sunk, the deepest on the Pride of the Pines and the Ben. Franklin. These proved the existence of true veins carrying gold and silver in the granite, but hostilities commenced too soon to permit further development. In the summer of 1870, when the northern portion of the Hualpais came into the forts, professing to desire peace henceforth, the southern part of the tribe refused to do so, and they have, up to this time, continued their depredations along the Mojave road, thus preventing a resumption of mining.

Sacramento or Hualpai district.—This is the only mining district in Mojave County in which actual work is carried on at present. It is situate on the western slope of the Cerbat range, thirty miles a little north of east from Hardyville on the Colorado River. The range here consists entirely of granite, syenite, quartzite, and hornblende slate, which contain an abundance of quartz veins, carrying lead, copper, gold, and silver. The Hualpai Valley, east of the range, and Long Valley, west of it, are not wooded, but are thickly covered with grass, which ascends to the highest ridge of the mountains. In the ravines and gorges toward the top of the ridge much cedar, juniper, and nut pine is found; and on the east slope is one large valley, which is thickly covered with cedar down to the level of Hualpai Valley, and on the side of the mountain, facing north, timber grows in abundance from top to bottom. This district is also better supplied with water than most of those along the Colorado River, nearly every gulch containing a spring. The water is excellent until it reaches the lower part of the ravines, where it becomes alkaline and sinks soon. There is one small creek in the district, which contains running water at all times of the year, except in the very dryest seasons, when the water stands in pools along its bed, sinking and reappearing for a distance, and finally being lost altogether in the sand below.

The first discoveries in this district were made in 1864, and already in 1866 work had to be suspended on account of the hostility of the Indians, who killed several miners and drove away the rest. Since the late reorganization many of the old leads have been jumped and named according to the fancy of the claimants. A few of the old locations have, however, retained the old names, the owners having been on their guard to at once take the necessary steps to resecure their property by complying with the new mining laws. In visiting the district, I have

examined only those veins on which work had been done lately, the shafts of the others being mostly inaccessible at the time.

The Noodle is a location on a large quartz vein, 4 to 6 feet wide, which crops out like a wall above the country rock. Syenite forms the hanging, and quartzite the foot wall. It strikes east and west and dips steeply north. Little has been done on it, but in a small cut streaks of galena are seen, not sufficiently concentrated on top to encourage much work. A good spring is close to it.

The Woodworth, a ledge cropping from 5 to 12 feet high above the surface, is located on the main ridge of the range, and has been traced some distance on both slopes. It strikes east and west and dips north. The croppings show galena all over. In a prospecting shaft 6 feet deep, the vein is 5 feet wide and shows two streaks of more concentrated galena, one 4 to 6 inches near the hanging wall, and the other 1 foot wide on the foot wall. It lies in fine-grained syenite and is easily followed for a long distance toward the Hualpai Valley. There is plenty of timber all around it.

The Alcran, one of the veins discovered during the first occupation of the district, has had considerable work done upon it. The vein stands very nearly vertical in syenite, strikes east and west and is best exposed on the eastern slope of the mountain. The shaft sunk on it is partly filled up, and only for a distance of 35 feet preserved so that the size and character of the vein are plainly visible. It is here 3½ feet wide, and contains above quartz with carbonate of lead, much iron stained and containing gold. Lower down a solid mixture of galena and dark zincblende occupies the fissure. The mouth of the shaft is from 1,600 to 1,800 feet above the Hualpai Valley. The neighborhood is heavily wooded, but water is one-half mile distant. The location is within two miles of the line of the thirty-fifth parallel railroad.

The Hancock or Buckeye is also a vein originally discovered in 1864, and abandoned in 1866. This is a small vein, being only 4 to 8 inches wide. It stands vertical in syenite, strikes east and west across the main ridge, and has been followed and opened by prospecting holes for some distance on both slopes. It contains copper-silver glance, galena, and malachite, the former predominating, and assays high in silver. The mineral is so concentrated that it would probably pay to mine and ship the ore, but it is proposed to use it with galena in smelting furnaces to be erected below. The location comprises 1,800 feet.

The Savage, a contact vein between greenstone porphyry on the foot wall and syenite in the hanging walls, is located on the south side of one of the western spurs of the main ridge of the mountain. Like the porphyry dike, which cuts through the syenite, it runs east and west and dips north. In a prospect hole 6 feet deep the vein is seen to be 2 feet wide. The croppings are a soft brown quartzy material, and immediately below the surface the crevice is filled with a mixture of carbonate of lead and bunches of undecomposed galena. This ore is sufficiently concentrated to be at once available for the furnace. It contains sufficient oxide of iron, argillaceous matter, and quartz, to form a good slag. Location 1,400 feet.

The Orphan Boy is a ledge running along the lower side of the porphyry dike just mentioned. It is little opened, but shows streaks of galena and carbonate of lead in the croppings and prospect holes. Location, 1,400 feet.

The Union is the most important vein of the district. It is, like the foregoing, a contact vein, porphyry forming the hanging and syenite the foot wall; but is lower down the hill. It also strikes and dips con-

formable to all the others in the district. The vein is from 6 to 12 feet wide and crops out boldly above the surface. There is a shaft, 13 feet deep, sunk on it near a small ravine crossing it, and an open cut has lately been commenced from the ravine toward the shaft. In both these openings a large solid body of galena is exposed, the greater portion of which is pure. The part of the vein near the foot wall contains an admixture of some copper pyrites, and near the hanging wall is a narrow band in the coarse-grained galena, which is finely crystalline and assays very high in silver. There is no gangue whatever in this body of ore. The coarsely crystalline portion of it assays 60 per cent. lead, $18 per ton silver, and $8 gold; the rest is zinc, copper, sulphur, and some iron; the fine-grained band referred to above has yielded in three assays, respectively, $131, $152, and $253 per ton in silver, but such ore is limited in quantity.

The Union is one of the veins discovered several years ago; and work has been resumed on it during last summer. If properly worked it must prove a fortune to its owners—the ore supply being apparently unlimited.

There is a large spring in the ravine immediately by the side of the shaft; and in the shaft itself is much water. Plenty of timber for mining and smelting purposes is in a radius of three miles from the mine, but the best timber for coal is higher north, in the Cerbat Range, and in the next mountain chain to the southeast.

Some 2,000 feet are claimed in the original location of this lode, over 1,400 feet of which are owned by one man. There are several extensions unopened.

The Bismarck, immediately above the first spring in the big cañon directly east of Union Pass, is slightly opened and shows about 1½ foot of quartz, through which much galena is scattered, and 10 inches of solid carbonate of lead and fine-grained galena. It runs east and west, like all the others. Location, 1,400 feet.

The Antietam is a copper lode 3 feet wide, about five miles north of the foregoing. The ore is very rich in copper, and carries much silver and a little gold. A shaft 40 feet deep has been sunk on it formerly, but work has not yet been resumed.

The Blue Bell, Darby, Daniel Webster, and many others, are locations formerly made, on some of which considerable work has been done. They all contain gold and silver, but have not been reopened as yet.

The Sacramento district is better situated, in regard to water and fuel, than most of the Colorado River districts, while as to cost of transportation it far surpasses the mining districts of Middle Arizona. Ore can be shipped to Cottonwood Island, on the Colorado River, for from $15 to $20 per ton, and from that point to San Francisco, by water, for $20. This is, of course, still high freight, but by smelting the ores into pig-lead, in which the silver will be found concentrated, before shipping, mining in this district can well bear it. Miners' wages are from $60 to $75 per month and board.

The veins of the Sacramento district strike and dip different from those of the Sierra Prieta, and have a different character, a fact which deserves to be noted as probably referring them to a different age. The country rock here contains no olivine, which is abundant in Middle Arizona. I am inclined to believe that the veins of the Cerbat Range are the oldest.

San Francisco district.—The "Black Mountains," described in a former part of this chapter, have a small group of hills running out from them

toward the southwest, opposite Hardyville, on the Colorado River. In these hills the San Francisco district is located.

Several of the lodes discovered in it raised a wild excitement at the time of their discovery, and the "Moss lead," especially, contributed much to this when it became known that several hundred pounds of the croppings sent to San Francisco had yielded at the rate of several thousand dollars in gold per ton. At present not a single vein is worked here.

The Moss lead is a large quartz vein in gray felspathic porphyry, running northeast and southwest, and dipping 70° southeast. The outcrop of this remarkable ledge stands like a wall above the country rock; is 12 to 30 feet wide, and can be followed with the eye for more than a mile. Much work has been done here in tunnels and shafts with a view to strike the vein at a little over 100 feet below the croppings; but the tunnel has never struck the vein, and only one of the shafts has reached it. In its bottom is said to be good ore. The tunneling works, as well as one of the shafts, are remarkable specimens of mining engineering, such as have ruined many other mining enterprises, besides the one under discussion, in the West. The tunnel was started in from a ravine below the foot wall of the vein, and run for a long distance obliquely toward it, so that it might have reached the vein, if continued in that direction, in about 2,000 feet; while, if the direction had been taken from the start at right angles to the vein, the distance to be traversed would not have been more than 300 feet. After having driven the tunnel far into the porphyry in the direction indicated, the second mistake was made by coming back some 30 feet from the end of this drift and starting another one in its left side at right angles to the former direction, instead of obliquely and at right angles to the vein. This has never reached the vein, but an air-shaft, the top of which is close to the hanging wall of the vein, shows the tunnel face to be close to it. A winze is sunk in the first tunnel and one in the drift at right angles to it, for what purpose cannot be imagined, as the vein dips away from the tunnels. Many crosscuts in the porphyry are also made from the tunnel, partly running parallel to the vein and partly at right angles to it, but none reach it. One shaft is sunk in the foot wall of the vein from the surface, and has, of course, never struck it; while another one, in the hanging wall, has, as before mentioned, reached it at a depth of 80 feet. Whoever planned these works must have evidently seen drawings of mining works in depth, without understanding their import.

A portion of the outcrop has been quarried and worked in the mill of the company at Hardyville, on the Colorado, nine miles off. The returns were not satisfactory. The gold, though abundant and showy in spots, seems to have been badly distributed. The assay record at the mill, at least, indicates this. The quartz is dense, slightly iron-stained, and looks more like a metamorphosed sandstone than like gold quartz. It contains, at the croppings, patches of heavy spar and felspar. Nevertheless, it cannot be said that the working of the vein has proved against its value, for the vein, beyond a single spot at the croppings, has never been worked.

An excellent stone boarding-house was erected near the mine by the company; also, the necessary blacksmith shops, &c.

The road from the mine to the mill leads down a broad arroyo, with very sandy bottom throughout. The mill buildings, dwelling-houses, assay office, carpenter shop, &c., are all constructed of adobe, and have shingled roofs, the shingles for which had to be brought many miles from Central Arizona. The mill has ten stamps, four pans, two wooden

and one small iron settler, and is run by a 30-horse power engine, which also pumps the water up into a tank above the mill from the Colorado River. Although the machinery has been idle for several years it is well preserved and ready for use at the shortest notice. There is a large supply of firewood piled up at the mill.

The Southern Cross is a vein upon which more work has been done than upon all the others in the district together. About $70,000 has been expended in tunneling and shafting, all of which is well planned and executed, but it establishes beyond a doubt that the Southern Cross will never support a prosperous enterprise. It is located exactly west of Beale's Pass in the Black Range, in the same group of hills as the Moss lode, but one and one-half miles southeast of it. The vein runs northeast and southwest, dips 60° northwest, and is 8 feet wide. Several side veins, like the Michigan, Silver Witch, and Gould and Curry, run into the main vein. The first-named of these was 1 foot wide, and contained a rich chimney of silver ore, 75 feet in length and 15 to 20 feet deep, which has been taken out and milled in the Moss Mill. The yield was about $18 per ton, while the pulp assays were over $30. There are five long tunnels, four of which are driven on the course of the vein at different levels below the top of the ridge; the fifth, the Parson, is driven at right angles to the vein, and if it had reached it, would have tapped it at 500 feet below the outcrop. The length of the tunnels is as follows: Parson, 600 feet; Michigan, 700 feet; Tom Paine, 500 feet; Dodd, 125 feet; and one without a name, 90 feet. There are also five shafts sunk on the ledge, of the aggregate depth of 260 feet. The vein is continuous, stands in a light-colored porphyry and consists of very white quartz with baryta, felspar, fluor-spar, (green and violet,) and great masses of manganese-spar; it also contains here and there manganese in the form of manganite. Silver ores, containing gold, were found in stripes and spots in the main vein, but were rare, though rich when found. The character of the gangue of this vein is eminently that of a true silver vein, but the occurrence of the metal is too rare and spotted to make a continuance of the work desirable.

The Queen of the Pacific is an extension of the foregoing. About $10,000 have here been expended in shafting and tunneling, but nothing different was elicited from the experience in the Southern Cross.

The Leland, five miles south of the above, and the Mitchell, 1½ miles from the Leland, are both gold lodes. Considerable work has been done on both, but unsuccessfully. The company owning the latter erected a mill, Thunderbolt crusher, and pans, six to eight miles from the mine in the Colorado bottom, but the ore brought to it gave unfavorable results. The abandonment of all these mines was hastened by the outbreak of the Hualpai Indians in 1866.

Along Silver Creek (the ravine in which the road from the Moss lode to the Colorado is located, and which contains running water at its upper end for some distance) the ruins of Silver City, a once populous town, are yet standing. There is not a soul living there at present.

PAH-UTE COUNTY.

This county forms the northwestern corner of Arizona Territory, and is bounded by Mojave County on the south, and by Yavapai on the east. In this county occurs the wonderful "Great Cañon" of the Colorado, and the hardly less sublime gorges through which the Diamond River finds its way to the Colorado. In the part of the county which, if the cession of a portion to Nevada is to be considered as final, remains with

Arizona, no mines are at present known to exist. The country is described by the few explorers who have traversed it, as extremely barren and desolate, destitute alike of vegetation and water, except near the rivers. On the west bank of the Colorado, however, is a locality which promises to contribute largely to the product of precious metals.

El Dorado district.—This district lies immediately on the Colorado River, in the low hills at the base of the Black Mountains, which here cross the Colorado. The porphyries and trachytes of the main ridge are here accompanied by metamorphic slates leaning against them, and here on the western slope of the range occur a number of veins conformable in strike and dip with the slates. The gangue of the veins is quartz and calcspar, and there is much slaty matter scattered in them. The ores are horn-silver, vitreous silver, stephanite, and fahlore, associated with ores of copper, antimony, lead, and iron pyrites. The ores also contain some gold.

The Techatticup is the principal vein of the district. It varies from 7 to 9 feet in width, and the mineral is mostly distributed through the lode in small pockets. The vein was attacked in various places, and sunk upon to a depth of 150 feet. At the surface much chloride of silver, averaging \$65 to \$70 per ton, was found, but with depth the base metals became more frequent, and the average value of the ores receded to \$45.

This company erected a mill at the Colorado River, and prospered as long as the free surface ores had to be worked. But when the sulphurets and antimonious ores had to be encountered, the results were unsatisfactory. Roasting the ores preparatory to milling would obviate all difficulties in this respect, but as yet no apparatus has been erected, and the mill has been idle during the greater part of last year.

It is reported that the company intended to resume operations at an early day, and there is, indeed, no reason for discouragement. One of Mr. Stetefeldt's chloridizing roasting furnaces erected in this district would soon restore the good name which the mines here enjoyed previous to the stoppage of the mill.

There are several other veins in the district on which work has been done, but none of them have been in operation during the last year.

On the Rio Virgen, not far from its banks, and not more than thirty or forty miles from the Colorado, occur the immense deposits of solid rock salt, specimens of which are distributed all over the United States. I was sorry not to be able to visit this interesting locality. Several tons of the salt which I saw at Hardyville were entirely pure, and the blocks were only covered with mud on the outside. They were not taken from the main solid deposit, but gathered up around its edges, where they were scattered in the plain.

YUMA COUNTY.

Lying south of Mojave County, and extending from Bill Williams's Fork to the Sonora line, and from the Colorado to the southern continuation of the eastern line of Mojave, this county forms the southwest corner of the Territory. It is entirely underlain by Quaternary and Tertiary strata, which surround a great many mountain ranges, all running northwest and southeast, and consisting of erupted rocks. With the exception of the Colorado and Gila bottoms, and the first terraces above them, the country is nearly destitute of trees, and the great bulk of it contains little pasturage. Very little water exists away from the two rivers and Bill Williams's Fork, but the mountain chains are rich in

minerals, and their contiguity to the Colorado renders shipping of the base-metal ores profitable.

Williams's Fork district.—This copper district contains perhaps the richest copper ores in the world. It is located twelve miles from the Colorado River along both banks of Bill Williams's Fork and one hundred and eighty miles north of Arizona City. There is a sufficiency of poplar, mesquite, and willow, in the vicinity, for smelting purposes, and plenty of water.

Owing to the low price of copper, very little has been done here of late years, and no new developments have been made since Mr. J. Ross Browne made his report of this district in 1868. To his description of the copper deposits of this region I have only to add the following: Protogine, granite, syenite, and basalt, with red conglomerates and sandstones, are the rocks of the district. The copper deposits have all heavy gossan outcrops, which have to be sunk upon for some distance, before the decomposed ores of copper are reached. These are of high grade and of great variety, comprising almost all the known kinds. Of sulphurets both the gray and the yellow occur.

The Planet, Eliza, and Knowles, Martin & Co.'s mine are the most noted. Thousands of tons of high-grade ore (above 30 per cent.) have been shipped from them, and many tons of the lower-grade ores have been smelted in a single smelting, into "black copper," in the district, and then shipped to San Francisco. At the time of my visit to Arizona only a few men were in the district to watch the furnaces and other property of the companies, and no work had been done at the mines during the year.

At Empire Flat, ten miles lower down the river, and close to it, occurs a group of veins in metamorphic slates and granite, which are rather peculiar in the arrangement of the ores they contain. They consist of layers of quartz in the vein, which carry gold, while the adjoining layers are rich decomposed ores of copper.

The Los Angeles has an iron cap of two to three feet in depth, part of which contains gold. Below this occur nests of green, blue, black, and red copper ores, sometimes very large. The brown ores between these nests contain gold, sometimes as much as $300 per ton. All the work done on this vein is near the surface.

The Challenge contains less gold, but the decomposed copper ores, many tons of which have been shipped, contain up to 40 per cent. of copper.

At Kangaroo Hill a gray limestone contains many narrow seams of brown hydrated oxide of iron which carries gold.

The veins at Empire Flat, containing gold, are mostly in talc and clay slates. A record of assays of ores from this place was exhibited to me, many of which showed $140 gold per ton, and some copper ores, containing from 23 to 44 per cent. of copper, yielded from $122 to $170 per ton in gold. The copper ores were shipped from the river to San Francisco at a cost of $18 per ton, while the hauling to the river cost $10.

La Paz district.—A granite range six miles northeast of the town of La Paz contains this district. The road to it leads over a hard mesa, and passes at the so-called water-tank, four miles from La Paz, an interesting locality. At this place the bed of a ravine is about 25 feet below the surface of the mesa and in its sides a white limestone, striking northwest and southeast and dipping 25° southeast, is exposed, resting directly on the granite; it is 14 to 16 feet thick, and the lower portion of the bed contains fragments and seams of the erupted rock. It is to be re-

gretted that no fossils occur in this limestone; but its lithological character refers it to a recent epoch.

Two miles farther east, on the southwest slope of a bold ridge, and running along it, occurs the Conquest lode. A belt of talc-slate, about 50 feet wide, runs here through syenite in a northwest and southeast direction, dipping 20° northeast into the hill. In it occur seams of quartz, sometimes running apart from each other and parallel, and then joining again, but the main direction is always parallel to the slates. This quartz is in places surprisingly rich in gold. The southeast end of the claim is about 275 feet above the bottom of the ravine. Progressing from here toward the other end of the claim, the following work has been done on it:

The discovery-hole, 10 feet deep at this end, shows three seams of quartz of respectively 2 feet, 1 foot, and 6 inches width, with horses of slate between, making the whole width of the vein at this point about 7 feet. The quartz is mostly dense and white here, only the middle seam being porous and iron-stained. The next opening is 30 feet to the northwest, 6 feet deep, and shows the same arrangement of the seams. One hundred feet farther are three small shafts, exposing the same character of the vein. In the open cut and 15-foot incline, and a 10-foot incline met with further on, iron-stained quartz in many small seams is seen, and some spurs join the vein, coming in at right angles from the hanging wall. Next, in an incline 45 feet deep, the vein is 6 feet thick, and, for the first time, solid, iron-stained, and containing visible free gold. An open cut exposes the vein from here for 30 feet; another one, 20 feet long, is a short distance farther on; and here the vein is much scattered again, but the ore is very rich. The main work on the vein, two very large open cuts and a shaft 70 feet deep, are next reached. The vein-matter is scattered here over a width of 30 feet; but much free gold can be seen in the quartz seams. Here the zone of slate makes a sudden turn more to west and is not much opened below this point. In the last-mentioned open cuts and shafts spots of the size of a fist and larger are seen in the quartz and the slates, entirely filled with soft pulverulent hydrated oxide of iron, which prospects exceedingly rich in coarse, free gold; it is worth $19 per ounce. At least 1,200 feet of the 1,600 feet located are more or less opened, and the ore so far has been found good. It is the intention of the owner to tap the vein by a tunnel which, with a length of 150 feet, would strike the lode at least 200 feet below the croppings. There is much ore taken out from this vein and ready for reduction; but so far no machinery has been erected.

The Constantia is six miles southeast of the foregoing. The trail, as long as it crosses the main mountain, leads over syenite and talc-slate; but as soon as it descends to the lower foot-hills on the east it strikes greenstone and metamorphic slates, all running northeast and southwest. In a belt of talc-slate lies the Constantia. It is an enormous vein, the croppings of which are seen for over 1,000 feet. For that distance it is from 30 to 50 feet wide, but at both ends it becomes much narrower and finally disappears. The vein dips 25° southeast. Much of this quartz vein is porous and highly iron-stained, and in one of these softer layers a shaft 50 feet deep has been sunk. There are from 20 to 30 tons of ore on the dump which shows free gold occasionally. Some of the quartz was formerly worked in arrastras at Tyson's wells, about four miles to the east, where the nearest water is found in a deep well, and the result is reported to have been a yield of from $20 to $35 per ton. But nothing has been done on the vein for several years.

Farther to the southeast, near the road to Wickenburg, many veins

containing lead and copper were located several years ago; and some of them were opened by shafts and tunnels, but none of them have been in operation during the last two years.

The gold placers in the vicinity of La Paz, which extend over an area of at least twenty miles in all directions, deserve some notice. A very good history of them is given in J. Ross Browne's report of 1868, and it remains only at the present time to say a few words as to their probable origin. They are undoubtedly of local origin. The syenite and the metamorphic slates contain many large quartz veins, but the almost incredible number of small gash-veins in the slates and greenstone have probably furnished most of the gold. The gravel is not rounded, like fragments of stone exposed to the action of running water for a long time, but angular and sharp-edged. There is very little earth mixed with it on the sides of the gulches and none in the ravines themselves. The gravel is never deep, hardly exceeding a depth of 5 feet.

There being no water in the vicinity, nor in such a position that it could be brought to the placers, the gold has been so far extracted by dry-washing. A machine constructed for that purpose was in operation in some of the gulches during last year, but it had lately been moved from the place where it was known to have been at work, and I could, therefore, not witness the operation. The results reached with it are claimed to be very satisfactory. As only the coarse gold can be got by dry-washing, these placers must be still far from being exhausted, though they have been worked over to a great extent. The amounts taken out formerly per hand per day are reported fabulously high, but much more gold remains now, though for the present inaccessible, than has ever been taken from these diggings.

Eureka district.—This district is forty-two miles north of Arizona City on the Colorado River, and the veins are from one mile to fifteen miles east of the river. The district is an old one, having been organized in 1862. The country rocks are granite, slates, and porphyry, and the veins are mostly contact-veins, striking west-southwest and east-northeast, and dipping at an angle of about 45°.

The Margarita is 3 feet wide and has been opened better than the other veins by numerous shafts and levels. The gangue in depth is mostly calcspar and quartz, which carries argentiferous galena containing from $60 to $100 in silver. Much ore has been shipped from this vein to San Francisco.

The Rosario is within a short distance of the river. The shaft is 60 feet deep and contains a 2-foot vein, which carries mostly zinc-blende containing $7 per ton in silver. At other places the same vein contains galena, assaying as high as 74 ounces per ton in silver. A tunnel, now in 200 feet, is intended to strike the shaft at 300 feet.

The Buena Vista, Bronze, and others have also been opened in this district and all of them carry argentiferous galena. None of these mines were in operation in 1870.

Across the Colorado at this point, on the California side, the same belt of rocks appears. Here five or six mines are opened, mostly occurring in the neighborhood of trachyte dikes. They contain galena with iron pyrites, and this ore is both argentiferous and auriferous.

The Mammoth is a representative vein of this kind. The shaft is 80 feet deep. The arrangement of the ore in this vein is rather peculiar, different minerals lying in slightly inclined layers above each other in the same vein, as, for instance, in the first layer, galena, the second, iron pyrites, the third, zinc-blende, &c. These pyrites yield, by assay, 2 ounces gold per ton, and 0.77 ounces silver; the blende, 5.83 ounces silver; the

galena, 122.47 ounces silver. Higher up on the mountain the galena in the same lead is very solid and contains 57.5 per cent. of lead.

Mr. Peabody worked another vein on the same side of the river, specimens from which assayed 61.5 per cent. of lead, 55.5 ounces silver, and 0.17 ounces gold per ton.

Castle Dome district.—This district is situated opposite a point on the Colorado River, thirty miles above Arizona City and inland to the east about twenty miles. It was organized in 1863 and 1864, and some of the mines have been in operation more or less ever since. The district has its name from a dome-shaped butte, which towers several hundred feet above the crest of the mountain chain, and is visible for great distances in all directions.

Castle Dome district has a very rugged surface, and the mines are not easy of access. Water is rather scarce, and wood is confined to cottonwood, mesquite, ironwood, and palo verde, the first only near the Colorado, while the two latter kinds occur in limited quantity in all the dry washes and ravines from the mountains.

The Castle Dome Mountains are an isolated range running northwest and southeast, and extending twenty-five miles from a point near the Gila toward the northwest. The range is entirely destitute of vegetation. The rocks constituting it are granite, metamorphic slates, basalt, and porphyries; the erupted rocks especially give to the outlines of the chain that ragged appearance so characteristic to it.

Prospecting in the mountains proper has so far been devoid of satisfactory results. Exceptional seams of yellow and blue talcose clays are met with; also several large veins of hard, dense quartz, slightly tinged with oxide of iron, but they are not auriferous. One of these veins can be traced through the mountains for several miles, having withstood the action of the elements, while the neighboring rocks were destroyed and washed away for many feet in depth. This ledge is from 3 to 20 feet wide, strikes north 40° west, and dips about 25° southwest. On one casing beautiful dark dentritic forms are seen, and pieces of this sometimes contain visible gold; but on the whole the vein is barren.

The district was first entered by Americans in 1863, but old and abandoned mines with shrubbery of many years' growth upon their dumps, a well-beaten trail to the Gila, piles of slag and traces of ruined Spanish furnaces near that river, clearly demonstrate that this ground was known and worked by the Mexicans prior to the occupation of the country by Americans.

The founders of the district (as is related by one of them) labored under the delusion that galena was nearly pure silver, and that in the possession of mines here they had a "big thing." They suffered from want of water, provisions, and mining supplies; yet they worked here during the summer heat, Sundays and nights, as well as by day, sustained by the consciousness of being in luck. No efforts were made to explore mines or to extract ores; all their energies were centered upon the acquisition of ground by posting notices and complying with the district regulations in regard to work, &c. Several months elapsed before satisfactory assays could be obtained, when the mere word "lead" destroyed their hopes, and dispelled their bright illusions as the splash of a stone effaces the reflection of scenery from the face of a placid lake. The reaction was great, and the disappointed miners were easily called away by the reports from La Paz, Weaver, and other rich placers. Castle Dome was again a solitude. Later, the establishment at San Francisco of smelting furnaces and lead-works created a demand for lead ores, which again brought this district into notice, and veins here were worked with varying success until the opening of sim-

llar mines in California and Nevada, from being nearer at hand, diverted the attention and money of capitalists, who had been promoting operations down here. Many promising veins were abandoned for want of capital. This winter work has been resumed on several lodes with highly gratifying results. The books of one mine, the Flora Temple, show that the first 100 tons of ore were placed upon the dump, cleaned and ready for transportation at an expenditure of less than $900, which includes cost of tools, supplies, and every expense incurred in the discovery and opening of the mine. The ore is an argentiferous galena, and assays 63 per cent. lead and 39 ounces silver per ton. The mines are perfectly dry, no moisture having been found at the greatest depth yet reached. On the score of security, economy, and facility for working, the absence of water underground amply compensates the trifling inconvenience of having to use it from barrels. Water is hauled to the mines from the Colorado River by the teams employed in carrying ores down to the landing. Fuel is abundant in the ravines, which are well stocked with a species of lignum-vitæ, known here as "ironwood." The country rock in the small district in which mines are actually worked is slate and granite. The most prominent lodes appear to be true fissure-veins, running north-northwest and south-southeast, dipping indifferently to east or west. The principal characteristic is a gangue of fluor-spar, tinged pink or green, and sometimes beautifully crystallized.

The Castle Dome mine, now being worked with great vigor, contains 2,200 feet, acquired by location and purchase. One hundred and sixty feet have been opened and worked to the depth of 56 feet, producing some 500 tons of shipping ores. The greatest depth attained in exploration is 104 feet. Surface explorations clearly establish its continuity. It is producing ores of excellent quality, assays of metal now *in transitu* to San Francisco ranging from 58 per cent. to 69 per cent. lead, and $23 to $190 silver per ton.

This mine is particularly interesting from the diverse character of its contents and the beauty and richness of many of their combinations. Sulphurets and carbonates, and a half-decomposed galena, dull in color and exceedingly rich in silver—chemical composition as yet unknown—are generally selected for shipment; the poorer carbonates and sulphurets being retained with an ultimate view to smelting at the mine or at the Colorado River. The strike of the vein is north 44° west; dip, 15° west. The foot-wall is a talcose slate, with a pink tint. The vein-matter contains many combinations of clay, talc, gypsum, fluor-spar, &c., of constantly varying color and consistency. The vein proper varies in width from 2 feet to 8 and 10. The shipping-ore generally occurs in compact seams, from 3 inches to 2 feet in width, though frequently met with in kidney-formed masses in spar and in the argillaceous and talcose vein-matter. The expense of extracting and cleaning the ore varies with the character of the vein. The following figures will be found as nearly correct as it is possible to give them:

Extraction and cleaning, (estimated)	$10 00
Sacks, per ton, (estimated)	2 00
Freight to Colorado River, (actual figures)	10 00
Freight to San Francisco, (actual figures)	15 00
Lighterage to reduction-works, (actual figures)	1 50
Assay and incidental, (estimated)	1 50
Total expense per ton	40 00

The Buckeye was worked very profitably last spring, until the approach of hot weather, by Messrs. Butterfield. Work has not been resumed yet this winter, though the mine shows plenty of ore and invites labor. It is of the same general character as the Castle Dome.

The Flora Temple was first opened this winter; has three incline shafts sunk to a depth of 50 feet, and the necessary drifts to facilitate communication and ventilation. From this limited amount of work (the stope remaining untouched) 150 tons of clean ore have been extracted.

The Poorman is yielding galena of first-rate quality, and its owners appear well satisfied.

The Prosperity, Don Santiago, Nonpareil, and other veins, are being prospected with very promising results.

I am indebted for much of the above information to Mr. Geo. Tyng, superintendent of the Castle Dome mine, and to Mr. Julius Sieback, a mining expert of Arizona City, who has had much experience in the Colorado River mines and elsewhere.

The placers of Gila City.—Some sixteen to eighteen miles east of Arizona City, the Castle Dome range crosses the Gila. On the low foot-hills on both sides of the river, the valley of which is here about a mile wide, and in all the ravines and gulches in them, occur gold placers. They have been worked for many years, and although they have been worked over by dry-washing to a great extent, they are still rich in fine gold, which could not be reclaimed by that process.

The main mountain range consists here of granite and syenite, which is traversed by greenstone dikes. The foot-hills consist altogether of metamorphic slates, which contain a great number of small gash-veins and bunches of iron-stained quartz. As in the case of the La Paz placers, I think that the gold in the placers comes from these slates.

The placers extend along both banks of the Gila for ten or twelve miles, and several small towns like Gila City, Los Flores, and Oroville, owe their origin to the first gold excitement. They are now deserted and only inhabited by a few white men.

At Gila City a San Francisco company has during the last year erected works to pump the water from the Gila up into a reservoir on top of the highest foot-hills in order to work the placers of the vicinity by hydraulic power. They use a 9-inch pipe through which they pump the water, and their works had just been completed when I left the Territory. The first run they had made satisfied them of the value of the placers, and they were eager to continue their operations.

The gold shown to me was mostly coarse, but of very fine quality, being worth $19 75 per ounce. I was told that their apparatus for saving the fine gold had not been completed, but was to be put up soon. If the gold left in these placers is really sufficient to pay for such an expensive way of working them, the field is undoubtedly sufficiently large to last for years.

At Los Flores, on the opposite side of the river, a small five-stamp mill has been at work for a part of the year crushing gold quartz from some small veins in the vicinity. The enterprise seems to be a success, as an addition of five stamps to the mill is contemplated.

Most of the placer-mining in the vicinity is done by Mexicans and Indians, and for that reason it is very difficult to get any reliable data as to their yield, unless the shipments of Wells, Fargo & Co.'s office at Arizona City may be taken as a criterion. These amount to little less than $75,000 during the year, but much of this comes undoubtedly from other sources in the Territory.

PIMA COUNTY.

This county comprises all that territory in Arizona lying east of longitude 113° 20′, and south of the Gila River. Next to Yavapai it is the largest in the Territory. It contains some of the most fertile agricultural lands in Arizona, principally in the bottoms of the Gila River and its tributaries, all of which, however, require irrigation. The great expanse of country to the southwest and south of the Lower Gila is barren, and, in fact, a continuation of the Sonora Desert. The level surface of the Tertiary plains is here only broken by the appearance of numerous small mountain-chains, the rugged outlines of which are visible for great distances.

The first mining in Arizona by Americans was done in this county, but before them the Mexicans had for years extracted the precious metals from these domains. Old mines, now mostly caved in, and the remnants of ancient beneficiating works, especially in the southeast corner of the county, amply confirm the traditions of the Mexican population in regard to this.

The Ajo copper mines are located sixty miles south of Kenyon Station, on the Gila River. Kenyon Station is one hundred and thirty miles east of Arizona City. This makes a land transportation of one hundred and ninety miles to the Colorado, over a good natural road; the first sixty miles, however, are entirely destitute of water.

There are several veins in the district, all of which occur in granite and slate; strike northeast and southwest, and dip steeply to the southeast. The principal vein contains solid peacock ore in a fissure 27 inches wide. The main shaft is 150 feet deep, and in this water was struck at a depth of 140 feet, which had to be carried out on the backs of Mexicans. Several drifts and galleries were run from this shaft, in the majority of which the body of ore is much split up; in others it thins out to mere thread. The longest level is 100 feet in. In another vein the gangue is white quartz, which contains native copper, red oxide, and carbonates. It is 18 inches wide and a shaft is sunk upon it to the depth of 90 feet. From this a level is run 30 feet from the surface, 60 feet long; and another, 45 feet below the surface, is driven in 30 feet. The ore-streak in the vein is on an average one foot thick. Water was struck in this shaft also.

There are several other shafts on these veins, from 20 to 60 feet deep. In the latter, which is on the first-mentioned vein, only decomposed ores, very solid and rich, had been found.

There is much mesquite wood in the neighborhood, and water was struck in a ravine, in two wells, within 20 feet from the surface. Work is temporarily suspended on these mines, and will be resumed as soon as the completion of the South Pacific Railroad, opposite this point, on the Gila, will lessen transportation. The ores are extraordinarily rich and well fitted for concentration by a single smelting on the spot into a high-grade crude copper.

The country south of Tucson, in the neighborhood of Tubac, I have not visited. It was originally my intention to pay a visit to these regions and report upon the mines which had at one time such an excellent reputation and on which so much labor and treasure have been expended in the past. After waiting at Tucson over two weeks for an escort, (for no part of Arizona is worse infested with Apaches, and a small party of white men cannot safely travel in these regions,) and seeing no prospect of getting one without waiting three or four weeks longer, I concluded to turn north and examine some other portions of

the Territory. This resolution was hastened upon learning that no work whatever had been done on those mines for years, and upon reflection that, in that case, I would not be able to see enough in the broken-down shafts and drifts to repay for the long trip. At the same time Mr. J. Ross Browne, in his report of 1868, has treated these mines so fully, at a time when there was much more and better opportunity for examining them, and he has quoted such excellent authorities in that report, that I am fully satisfied that all has been said in regard to these mineral veins and their development that ever was learned by working them. From that report we must conclude that this part of Southern Arizona is full of veins, principally carrying true silver ores, which appear to occur under the same geological conditions as the silver veins of Northern Mexico, viz, in porphyritic and granitic rocks, or as contact-veins between these eruptive rocks and sedimentary strata, chiefly limestones.

Some of these veins have been worked in an exceedingly extravagant way. According to the reports of Kuestel, Pumpelly, Brunckow, Schuchardt and other noted mining engineers, it is certainly not the fault of the mineral deposits that they do not support flourishing mining enterprises even under the present high cost of transportation, but entirely of the management and the hostility of the Indians. The South Pacific Railroad will do away with the Indians and high transportation, and it remains to be seen whether the future managers of these mines will have profited from the dearly-bought experience in mining all over the West.

The Lee and Scott mine, about twelve miles due west of Tucson, has been worked to some extent to within a year or two ago. But although this mine is almost in sight of the capital of Arizona, the Apaches have driven off and killed the miners, and rendered work upon the lode impossible. This vein contains a mixture of galena and fahlore very rich in silver, the portion reduced on the spot having yielded at the rate of $125 per ton. Governor A. P. K. Safford, of Arizona, who has lately visited the mine, says in regard to it:

> The course of the lode is west-southwest to east-northeast; near the surface its width is 18 inches. The hanging-wall is smooth, but the foot-wall is somewhat broken, and near it are about 6 inches of very concentrated mineral. For the first 80 feet in the shaft the dip of the vein is very regular 45°, but at this point a large horse comes in and the ledge nearly pinches out. Below this horse, which is only a few feet thick, the vein becomes much nearer perpendicular and widens out. At 90 feet, water in small quantity was struck, and several feeders join the main lode. At the bottom of the shaft, 100 feet from the surface, the ledge is about 5 feet wide, inclosed in plain walls, and the mineral seems well distributed through the gangue. The character of the ore is the same as shown to you (galena and fahlore.) I could trace the croppings for some distance on the surface.
>
> In this district there are also some very rich copper and lead mines containing silver, several of which have been worked profitably in times past. But the constant depredations of the Apaches caused the death of many of the workmen and owners and rendered it impossible to keep any live stock; so work had to be abandoned. * * * Could we have protection I am certain many of these mines, as well as a great number of those south of here, could be worked now to a profit.

The following description of the country in the southeast corner of Arizona Territory, between the Rio Salado or Salt River on the north and the Sierra Cananea of Sonora on the south, and between the Rio Santa Cruz on the west, and the Sierra Dragones and the one hundred and ninth meridian of longitude on the east, has been kindly furnished to me by Lieutenant John G. Bourke of the Third Cavalry. This sketch was compiled from notes collected during the numerous scouts of Troop F, Third Cavalry, and especially during the one made in conjunction with the volunteer troops acting under the command of Governor A. P. K. Saf-

ford of Arizona. While absolute accuracy cannot be expected of notes so hastily taken, the sketch will nevertheless give an approximately correct idea of the features and resources of a region as yet so little known.

SOUTHEASTERN ARIZONA.

In its general features this portion of Arizona presents a constant succession of mountain ranges, spurs, and offshoots from the great central chains of the continent. None of these are of very great length, except, perhaps, the Sierra Blanca, but they all obtain a considerable elevation above the sea-level, and being cut up by deep cañons and gorges offer very often great obstacles to the construction of roads. Between these sierras are, in general, to be found level plains or "playas," covered with a good growth of the various grasses peculiar to the Southwest, and consequently well adapted to the purpose of stock-raising.

Commencing on the north, there is the Sierra Ancha, otherwise called the Tonto Mountains; immediately to the south and east, separated by the Rio Salado from the former, the Apache Mountains, cut up by cañons and ravines, but well watered; farther to the east, and upon the other side of the Rio San Carlos, are the Picachos de San Carlos; to the north, and slightly to the east the Sierra Natanes, and farthest to the north and making an elbow to the east and south, the Sierra Blanca and the Mogollon Mountains. South of the Apache Mountains, and bordering close upon the Rio Gila, (proceeding from west to east,) are the Sierra Pinal, Sierra Mescal, and the Cordillera Gileña.

Still farther south, and bordering upon the left bank of the Gila, are the isolated peaks called the Dos Narices or the Saddle Mountains and the northern end of the Pinaleño and Mount Trimble and Mount Graham. The Sierra Blanca trends from north to south for the greater portion of its length, but the short arm of this range has a general course from east to west. The Pinal, Mescal, and Cordillera Gileña cross the course of the River Gila obliquely, and the San Catarina, San Pedro, Pinaleño and some smaller ranges run also about northwest and southeast.

The Guachuca Mountains and the Sierra San José are upon the Sonora line, as is also the southern extremity of the Dragoon Range; the only other range of importance is the Santa Rita in the extreme southern portion of the Territory. It would be impossible to form from a sketch thus hurriedly compiled any accurate view of the general trend and arrangement of these ranges, while the lack of proper facilities prevents the completion of a topographical chart; yet as these mountains, in addition to being prominent landmarks, contain inexhaustible mineral treasure, it has been considered advisable to give them particular mention.

Among the "playas" of largest extent is the valley or "playa" of San Domingo, which extends on the east well into New Mexico. It has a few streams of no consequence.

The country in the vicinity of the capital is a large plain, extending from the San Catarina range on the north to the Sierra Mesteñes, or Whetstone Mountains on the southeast, and thence bearing away to the northwest until it runs into the plains bordering upon the Gila. The last, but most fertile and valuable, is the stretch of country from the southern side of the Sierra Mesteñes to the northern side of the Sierra Guachuca. Hemmed in on the west by the little hills called the Barbacomara, it unites at the eastern extremity of the Guachuca range with a fertile valley now belonging to Sonora, and bounded by the Sierra,

Guachuca and Sierra Cananea on the north and south respectively. This is the garden-spot of Southern Arizona. Abundantly provided with water by the Rio San Pedro, Rio Barbacomara, Rio Cananea, and their little affluents, it offers to the enterprising agriculturist a field of labor which would undoubtedly prove highly remunerative. Covered with rich grasses all the year, having an abundance of fine timber and building-stone in the neighboring mountains, it will yet prove to be one of the richest districts of the Southwest. In this favored section should also be included the valley of the Sonoita and the country around Camp Crittenden, which will, however, be treated of under the proper head. The rivers and streams are the Gila and its tributaries, some of which, however, sink before reaching the main stream.

The Gila rises in New Mexico, in the mountains north and west of Fort Bayard, flows in a tortuous course to west and somewhat to the south until it reaches the Colorado, at or near Fort Yuma. It is a very narrow stream, with a swift current, shallow during most of the year, but in the rainy season vastly increasing its volume. Its banks are fringed with cottonwoods, ash, and willows. Shortly after crossing the one hundred and ninth meridian it passes through an abrupt cañon, of no great depth, but great beauty; another cañon, called the Grand Cañon of the Gila, is passed before it meets the San Pedro. Much of the region through which it flows before passing Mount Trimble and Mount Graham shows decided evidence of volcanic action, lava, basalt, obsidian, and such minerals being found everywhere. West of these mountains the traces of water are upon all the hills.

The principal tributaries are (in Arizona) between 109° and 110° west, flowing in from the north, the Natros, the Prieto, the Bonito, and another stream to the east of the Bonito, and at present without a name. The San Domingo is supposed to join it from the south, but is an underground stream.

Between 110° and 111° west are, upon the north, the Rio San Carlos and the Wallen Creek, the latter an unimportant stream; upon the south, the San Pedro, a river of considerable length and consequence and the Rock and Deer Creek, these last being, however, dry during the greater part of the year. Between 111° and 113° west, upon the north are the stream called Mineral Creek and the Salt River, while upon the south there is the Santa Cruz, which sinks before it joins. Of these the Rio Salado, or Salt River, the San Pedro, San Carlos, Bonito, Prieto, and Santa Cruz, with their tributaries, will be considered. The Rio Natros more properly belongs to New Mexico. It has one affluent, the Rio Azul.

The Salado is formed in the Mogollon Mountains, by the junction of two small streams; flows in a general southwest direction, and empties into the Gila between 112° and 113° west longitude. Its main branch is the Verde, a considerable stream, which joins it from the north, but is beyond the limits of the district here described. The Salt River also has two small tributaries, the Pinto, (with its branch, the Pappoose,) and the Pinal, both of which rise in the Pinal Mountains, and flow north, joining the Salado about ten miles apart.

Rio San Carlos rises in the Sierra Blanca region, and after flowing southwest receives one branch, the Rio Alisos, about twelve miles above its junction with the Gila. Rio San Pedro is formed in Sonora, about thirty miles above the American line, by the confluence of two streams, the Rincon de Burro from the east and the Cananea from the west. These little streams rise in the mountains of the same name. The San Pedro flows north-northwest for about one hundred and fifty miles and

empties into the Gila, fourteen miles beyond the point where it (the San Pedro) has received its principal tributary, the Aravaypa. Proceeding down the stream from its source, there are from the east the San José, a small rivulet from the Sierra Dragones, Prospect Creek, and finally the Aravaypa. On the west there are one small stream from the south side of the Sierra Guachuca, the Barbacomora, and a brook from the San Pedro Mountains, about seventy-five miles from its source. There are others, but none of permanence or importance. The San Pedro along the longest part of its course flows between clay banks, and is very narrow; its valley is one of the most beautiful in the Territory, and will be in time filled with a prosperous population.

The Bonito rises in the Sierra Blanca, flows south through a wonderful cañon, and pours its waters into the Gila, about thirty-five or forty miles due west of the New Mexican line; it is very narrow, but very swift and of some volume. No tributaries of much account join it, and it is about seventy-five miles long. The Rio Prieto, for about twenty-five or thirty miles before entering the Gila, flows parallel to the Bonito. Its course beyond that is more to the southwest. It always contains a great deal of water, but the streams flowing into it are of little volume. The Santa Cruz rises in a spur of the Sierra Guachuca, flows south into Sonora until it reaches the town of Santa Cruz, where it bends to the west, and after flowing in this direction about thirty miles turns north-northwest, passing over the line into Arizona. It sinks just below Tucson, and its waters are supposed to reach the Gila near Maricopa Wells. The principal tributary of this river is the Sonoita, coming in on the east; there are also one or two affluents from the Sierra Guachuca. The entire valley of the Santa Cruz is very fertile, producing in great abundance nearly all the vegetables found in the Middle States. Barley is the principal cereal.

The future prosperity of this section will be mainly dependent upon two sources, mining and stock-raising. The indications of gold, silver, copper, iron, lead, and manganese can be observed in every mountain, the Sierra Guachuca being especially rich in the first three. Silver and gold, iron and manganese undoubtedly exist in great abundance in the elevated country bordering upon the Bonito and Prieto. A large silver lead has been discovered in the hills back of the village of Tres Alamos, while tradition has it the Cañon de Oro, in the San Catarina, contains a valuable mine formerly worked by the Jesuit fathers and by them abandoned on account of Indian depredations. Nearly all the valuable building stones are found. Granite, porphyry, and sandstone are in nearly all the mountains. Sulphate of lime, in the form of alabaster and gypsum, is met with in great quantity in the Aravaypa Cañon, while a valuable quarry of hard limestone exists near Camp Grant on the San Pedro, and an abundance of it is known to occur in the Sierra Blanca. The hilly country appears in general to be adapted to the rearing of sheep, while the less elevated portions could again, as formerly, be divided into large ranches for beef-cattle and horses. It is said that a generation ago, before the occupation of the country by the American forces, large droves and herds of mustangs and wild cattle were raised in the valley of the San Pedro and the Barbacomara, but the constant incursions of the Apaches have since occasioned the abandonment of most of the ranches. The great number of deserted corrals and houses affords ample and melancholy evidence that the Government has completely ignored the interests and advancement of this portion of its territory. The soil, though nearly always requiring irrigation, yields an abundant return for the labor bestowed upon it, and such is the genial

nature of the climate that two crops of vegetables can without difficulty be obtained every year. The only obstacle to the prosperity of the country, as far as natural resources are concerned, is the lack of wood, yet this want is more apparent than real. In the Sierra Guachuca, San José, Pinal, and upon the Santa Rita and portions of the San Catarina Mountains, plenty of fine pine timber is procurable, a large saw-mill being now in successful operation near the Sonoita settlement. The southern boundary of the "pine belt" of Arizona crosses the northern slope of the Apache Mountains. Cottonwoods, ash, and willows are found on the banks of all the streams, the first named being serviceable for posts and sills, but not of much account otherwise. The ash is a very hard wood and very durable. The "roble," or scrub oak, is encountered more frequently than any other tree except the mesquit; it affords very good fuel. The mesquite is a tree in favor of which much may be said; in the adjoining Territory of New Mexico it never reaches more than the altitude of a bush; here it attains the dignity of a tree. Trunk and branches furnish excellent firewood, but the heat evolved by the combustion of its enormous roots exceeds that of either the oak or hickory. The few specimens of furniture constructed from this wood indicate by their beauty and durability its value to the cabinet-maker. The "beans" are much relished as food by horses, and the Indians use them to make a kind of cake, which is not unpalatable. The gum exuding from the branches in the months of October and November is very similar to the gum arabic of commerce and is applied by the Mexicans to the same purposes and as a medicine. The piñon is something like the cedar, is a good fuel, and produces a quantity of balsamic resin which has the taste and odor of turpentine; the nuts are edible. The manzanita has a very fragile but handsome wood; the berries are similar to "bear berries."

This portion of Arizona is not as well provided with game as are the regions lying closer to the Sierra Blanca and those in the northwest, nevertheless, deer, antelope, and bears are by no means uncommon. Wild turkeys are often found, and so are ducks and quails. The fish are very insipid, excepting those found in the Santa Cruz.

The supplies of the country are drawn from three sources: from California, by way of Fort Yuma; from Guaymas, through Sonora; and from the city of St. Louis, *via* Santa Fé. The pressing need of railroad communication is manifest, and hopes are now entertained that the early construction of the thirty-second parallel road will soon remedy the deficiency. So much ability has already been displayed and wasted in demonstrating the practicability of the various proposed routes that the extension of the limits of this sketch for any such purpose would be unnecessary and uncalled for. One thing appears evident, that the Territories of New Mexico and Arizona would derive great benefit from the construction of the line, but the United States would derive quite as much and more. The early completion of a road from the Atlantic to the Pacific, over which travel would never be impeded by the snows of winter, coupled with the great development of trade between our own country and the Mexican provinces of Sonora, Chihuahua, and Durango seems to offer inducements not to be disregarded. Emigration pouring in would soon solve the Indian problem by the extermination or complete subjugation of the hostile tribes, while the Territory, finding its natural outlet to the Pacific in the annexation of the port of Guaymas, would soon take its place among the most prosperous of the Western States.

No part of the country can possibly offer greater inducements to the stock-raiser than the valley of the Barbacomara and the Upper San

Pedro. Covered with a perennial growth of the richest grasses, well watered by numerous springs and streamlets from the neighboring mountains, this region has a climate so mild that stock would thrive the year round without shelter, save that which would be afforded against the fervid summer sun by the numerous evergreen trees, extending well into the plain.

Nor is this country devoid of beautiful scenery. The cañons of the Colorado can scarcely surpass those of the Bonito, and of the Aravaypa. The walls of the former tower to an imposing height, (nearly 1,500 feet,) and present but one or two difficult avenues of egress for a distance of thirty or forty miles. The cañon of the Aravaypa has been referred to in the recent work of Dr. Bell, "New Tracks in North America." The country lying more to the south does not present as bold an aspect, the peaks being less elevated and the cañons less abrupt. The numerous valleys, each provided with springs or streams and clothed with verdure during the entire year, make the landscape more interesting, if less impressive. From the summits of the mountains, forests and groves stretch down the sides, affording an agreeable contrast to the extensive plains below. The abundance of wild grapes growing luxuriantly from vines which have embraced some of the oldest trees indicate the adaptability of the soil to the culture of this fruit. In the low-lands perpetual summer reigns upon the hills, and in the cañons spring is the only season, but upon the mountain-tops can be experienced winds as severe as those of a northern autumn.

CONCLUSION.

The development of the mineral resources of Arizona has hardly begun, although the territorial government has been organized about eight years. It will be asked why this is so, if the Territory really contains these various mineral deposits; and the invariable answer of those acquainted with the conditions surrounding mining enterprises in that country will be, because the Apaches infest the Territory. This one fact, coupled perhaps, in some parts of the country, with high freights, is really the principal obstacle, not alone to mining, but also to agriculture, and in fact all other occupations.

It is true, the southern and western portions of Arizona are excessively hot in the summer months, and water is here scarce in the mountains at that time, but the same may be said of portions of Nevada; yet mining is successfully carried on in that State, and assumes yearly greater proportions. Again, as to high freights, it is well known that all the Western States and Territories have had to contend, to within a year or two ago, with the same difficulty, and it did not prevent the mining of the precious metals, though it has crippled the industry very much in times past.

But in none of those States and Territories have the settlers had to contend with foes like the Apaches. Their hostility to the white man, as well as to other Indian tribes, has been displayed by them, and found vent for years in a sort of guerilla warfare, which, with the limited number of troops at its disposal, the Government has thus far found itself unable to terminate successfully. And, to aggravate the situation, the peculiar climate and configuration of the surface of the Territory are the best allies the Apaches could wish for. The broad gravel plains without water, as well as the rugged mountains, forbid a sufficiently rapid prosecution of the Indians, when, after their frequent foraging expeditions, they beat a hasty retreat to their mountain strongholds, where

they generally scatter in all directions. The Apaches are not a strong tribe, but very few of them can, under the circumstances, do a great deal of damage, and effectually prevent the settlement of the country, as long as it is not better connected with other parts of the Union.

But what the Government has not been able to do in the past the South Pacific or Texas Pacific Railroad will certainly do. As in the case of the Union and Central Pacific roads, it will attract population, and the citizens, less hampered in regard to Indians than the military powers, will soon dispose of the question in their own way. Supplies will be brought to the mines at rates permitting the industry to prosper, and safety of life and property will continually tend to expand it. As to the basis of all mining operations, the existence of the mineral veins, the foregoing report amply affirms their abundance, though not one-third of Arizona has been prospected, or even visited by white men. It must not be understood that the mineral deposits of Arizona, as a whole, are richer in the precious metals, *per ton of ore*, than those of other countries. If they were, they would be the only exception in the world. But the number of veins in these barren, rough mountains, and their close proximity to each other, are surprising.

It is, in this connection, remarkable that all the veins of Arizona have either a northwest and southeast or a northeast and southwest strike. This points to the formation of these two classes of veins at two different periods, and it will be interesting, at some future time, when the action of the eruptive forces in Arizona is better understood, to follow this subject further.

One class of mineral veins in Arizona, though very valuable, will require much capital and skill in their development, and in the extraction of the precious metals from their ores. These are the gold-bearing sulphurets of the Sierra Prieta, very much like those of a portion of Colorado, and equally difficult to treat. But even if none of the new processes now contemplated for the cheap beneficiation of such ores (by a roasting which will effectually free the gold, and by subsequent amalgamation) should prove successful, the construction of the Texas Pacific Railroad will render the application of the Plattner chloridizing process remunerative. Besides, many of those ores are sufficiently concentrated to permit the introduction of smelting works, by the use of which the highest and most perfect yield of the precious metals may be obtained, as soon as the railroad shall lessen the cost of transportation sufficiently to permit the shipment of base metals.

After the construction of the great southern transcontinental railway, Arizona will have nothing to fear in regard to its speedy development, and the mines especially will be foremost to build up a country which, so far, has been persistently decried by those who do not know or acknowledge the half of its internal resources.

Even for the present the mining districts adjacent to the Colorado River offer excellent chances for the investment of capital. But to build up a successful mining industry in those districts the ores must be beneficiated on the spot, and land transportation must be limited to that of the metals only. At the same time professional skill and economical business habits must be employed to work these ores. These qualifications, which cannot be acquired except by a thorough theoretical and practical education in mining have, so far, not been brought to bear in Arizona, except in isolated cases.

The total product of Arizona during the fiscal year 1869–'70, in gold and silver, does not exceed $800,000, coin value. This includes the value of several hundred tons of argentiferous lead ores, shipped from

the Lower Colorado. While this estimate may be too low on account of the omission of such amounts as have undoubtedly been carried off by Mexican placer miners into Sonora, it embodies all those values of which reliable information can be obtained in the Territory itself.

The decrease from last year's production is partly due to the stoppage during a great part of the year of the mills on Lynx Creek; principally, however, to the unexampled drought, which impeded both placer and quartz mining, and to the extraordinary activity of the hostile Apaches during the year.

CHAPTER VIII.

NEW MEXICO.

The product of gold in the Territory of New Mexico during the last year has been little in excess of that of the year before.

The Moreno gold fields, the principal part of which, the Maxwell grant, is said to have been sold to an English company during the year, have held their own, as a whole, the Aztec Mill having made up by an increased yield what was lost by the placers. The latter have had a better supply of water than last year, the Moreno ditch having been partly puddled and connected with additional sources of a water supply. Only the larger placer mining claims, however, have been worked during any considerable portion of the season.

Of twelve claims reported six have produced over $10,000, and the product of all the claims is about $110,000. The twelve claims mentioned have employed sixty-six men on an average of six months, paying wages of about $60 per month. The average yield per day per hand of these claims has been $9 70. The most productive claim has been that of Arthur & Co., which yielded $20,000, employing ten men during eight months.

The Aztec Mining Company, whose mine has been described in last year's report, has employed thirty men steadily for twelve months at average wages of $3 25 per day. They have extracted during that time over 3;500 tons of quartz, which yielded $76 76 per ton, or an aggregate of about $260,000. This yield is higher per ton than that of last year, and perhaps unique in the United States for so large an amount of ore.

The discovery of extensive deposits of bituminous coal on the Maxwell grant is important for the future of that portion of New Mexico. Several beds, some of which are reported to be 10 feet thick, have been found in the Raton Mountains, along the Red River and on the Vermejo. Along the course of the Upper Poñil and the Cimanoa Rivers other beds are said to have been traced. All of these are probably not coals, but rather lignites; but even if so, their discovery is a very fortunate event for a country in which timber is not overabundant.

The mines of the Arroyo Hondo Mining and Ditch Company, near San Antonio, in Taos County, which were mentioned in last year's report, on account of their great extent and the extraordinary facilities offered here for cheap reduction, on account of the low price of labor and the abundance of wood and water, the latter sufficient to drive a twenty-stamp mill, have not yet realized the expectations entertained in regard to them. The company have employed fifteen men during nine months, but realized only a little over $8,000. Wages are still low, $1 per day and board.

In Santa Fé County the old and new placers have again been worked, to a limited extent only, and the project of bringing water to these localities from the Pecos River has not yet been carried out.

The New Mexico Mining Company and the Candelaria Company are the only quartz mining companies reported at work during a part of the year. The New Mexico Mining Company at Real de Dolores has employed eighty men and some boys during nine months, and has crushed 1,800 tons of quartz, yielding a little less than $18,000, or nearly $10 per ton. This yield does not at all come up to the expectations entertained last year in regard to the ores of the Ortiz and Brehm lodes.

The Candelaria Company at Real del Tuerto has worked eight men for ten months, and 1,200 tons of quartz were mined by them. I am not informed of the yield of this ore; but as the company bought a ten-stamp mill last year, which had before crushed ore from the same mines with satisfactory results, it may be expected that the business of the company was a paying one, though wages have been much higher in this part of New Mexico than elsewhere. The Candelaria has paid $83 per month to its hands, without board; and the New Mexico Mining Company about $60 with board.

In Grant County little real mining has been carried on, while much prospecting has taken place.

The placers in the vicinity of Pinos Altos have produced little, partly on account of drought and the hostility of the Apaches, and partly because nearly all the floating population in this camp was carried off to the Burro Mountains by the excitement which broke out in the early part of 1870, on account of alleged rich discoveries of silver veins.

The quartz mines, too, have done little during the year, and of four companies reported only one has worked twelve months, the remainder having been active from one to four months.

The Pinos Altos Mining Company has only worked one month, and its product is less than $3,000. The remaining three companies, Reynolds & Griggs, Ryerson & Co., and the Asiatic Mining Company, have employed sixteen men, on an average of eight months, at $2 per day. They have crushed 3,970 tons of quartz, which yielded $60,900, an average of $15 33 per ton. The largest product is that of Messrs. Reynolds & Griggs, who crushed 2,880 tons, yielding $48,500.

The Pinos Altos region is one of the most exposed to the depredations of the Apache in all New Mexico, the distance to the Sierra Blanca and the Pinal Mountains, the strongholds of the worst bands of Apaches, being short, and military protection not in the immediate vicinity.

The celebrated copper mines of this region, in Central City district, which were described at length in last year's report, have not been in operation. But steps have been taken to secure United States title to the Santa Rita mines, and an early resumption of operations at this mine is expected.

The great events in reference to mining in the Territory of New Mexico are the simultaneous discoveries at widely remote localities of extensive silver veins and deposits. I refer to those made at the Burro or Pyramid Mountains, in Mesilla County, those in the Cienega and Chloride districts, in Grant County, and finally, those near the Rio Dolores, an affluent of the Rio San Juan, in the northwestern part of the Territory. The latter, though reported to be rich and extensive, have been less explored than those first named, the Ute Indians having prevented the prospecting party, when attempting to reach the mines the second time, from advancing in that direction, forcing them to turn north, where they are said to have discovered rich gold mines in the San Luis Park in Colorado.

The Burro and Cienega mines are better known, and, though no active mining of any account has been carried on in either of these localities, many outsiders, and among them intelligent mining men, have visited them and reported on their merits, as far as developed at present. Various accounts have appeared in the press from time to time in regard to the Burro mines. The following is from the pen of Mr. J. Wasson, surveyor general of Arizona Territory:

As these mines have attained celebrity, and are destined to be more widely and favorably known, their location should be described with approximate accuracy—all that any man can do at present. New Mexico claims them, and while Arizona does not deny

it, she does not admit it. The line between New Mexico and Arizona is established on the one hundred and ninth meridian of longitude west of Greenwich, and no line has ever been run or observations taken on it, not even at its intersection with the international boundary between Mexico and the United States; hence any positive opinion as to the territory in which these mines are situate would be presumption. Yet it is generally believed that the line between the Territories lies to the west about fifteen miles, and for legal purposes the authority of New Mexico is recognized. The mines lie just south of the Overland Mail and Stage road, and the bold croppings may be seen distinctly fifteen miles distant either way on the road. They lie at the extreme north end of the Pyramid range of mountains, where they lose themselves in the open, level country, forty-five miles east of Camp Bowie, at Apache Pass, and seventy miles southwest of Camp Bayard; by the sinuous road of Tucson, one hundred and fifty; and west of Mesilla, on the Rio Grande, one hundred and twenty. The stage passes weekly over this route, once each way, with the mails and passengers to Tucson and Mesilla. Fare to Mesilla, $35; to Tucson, $42 50; and thence to San Diego, $90—two trips each week west of Tucson.

Up to May 21st there were 1,257 original claims recorded, and they cover a scope of country about six miles in extent. But three monster veins are prominent—Harpending, Brown, and Arnold. They crop out for miles, in places 50 feet above the surface, and verging from a few to hundreds of feet in width. Between the lodes is a network of smaller ones, many of which are from 10 to 50 feet in thickness. The limited amount of labor performed forbids any correct opinion of worth, regarding the casing of the veins, extent or character much below the surface. In a few places slate walls have been exposed by the miners to a depth of several feet. Quite an extended observation of quartz operations in the Pacific States and Territories has convinced me that more failures have ensued because of a lack of ore than on account of its barrenness of gold and silver. Here the quantity is apparently unlimited. I was disgusted in advance with what I considered the same old stories about "any amount of ore—rely upon that." I felt that all former lying had been rendered insignificant in comparison. Yesterday and to-day I carried a hammer, climbed up over the scraggy croppings in scores of places, and knocked off pieces where others had not, and the amount of quartz in sight is so great as to make one doubt his sight—almost regard himself in the midst of a wild dream. I have neither seen nor heard any exaggerations with reference to the quartz in this district.

The quality is still a matter upon which the honest and well-informed may and do differ. I to-day saw boxed some forty pounds of ore from various mines, and addressed to A. Harpending, San Francisco, to be forwarded by stage to-morrow. It may be taken for specimens, but I am sure there are many thousands of tons equally as good in plain sight. If the ore which P. Arnold has forwarded to Mr. Harpending gives satisfactory returns of gold and silver, there can hardly be a doubt that this is the most extensive deposit of rich quartz ever found in America. The same quality of ore is abundant throughout the district. It is exposed in thousands of places, and not in small bunches. Speaking only in comparison with other ores, I believe those of this district will be proved of great average richness. I understand the tests so far made have shown but little gold; yet to-day I struck a small pocket which contained much free gold, as was verified by pulverization and careful washing. Unquestionably silver largely predominates.

There are many evidences that these mines have at one time been worked in a crude way, and the ore taken elsewhere for reduction, and that some of the mysterious and fabulous tales of silver mines in Mexico had their origin here. On the Roberts claim, on the Brown lode, is an old stone cabin. It was covered in the usual Mexican style until recently, when some soldiers set fire to it and burned off the roof. It was covered with cedar poles, thatch, and dirt. A hole near by, where the mortar was probably mixed, is grown up with small shrubs, and a portion of the limbs of a cedar tree adjacent have been cut off, and the marks of the ax are yet visible in the dead branches. The work must have been done many years ago. In the quartz near by there are crevices worked out into the heart of the ledge, some of the cavities being large enough to admit a man on his knees, and when discovered, the entrances were closed with rocks. In other places ore has evidently been taken from the surface, as the "deads" are as orderly placed to one side as is the practice of modern miners. At this city springs were dug out and walled up. Flat stones used in grinding grain for food are lying about. The careful observer here can have no doubts regarding these statements. The Apache Indians killed and drove men from highly cultivated farms in many sections of this country—why not from mines?

Large teams can easily reach the majority of claims, and with very little labor roads can be made so as to admit of heavily laden wagons passing to and from any of them with ease. The hills rise gently and are covered with a heavy growth of nutritious grass and scattering cedar timber of the scrub variety; are not rocky except near the veins, and there the boulders are quartz croppings. In most all quartz districts the item of roads is a big one in the expense account; here it will amount to nearly nothing.

In the gulch passing up through Ralston water is abundant in the rainy season, and for some time thereafter on the surface; new wells have been dug from 5 to 25 feet

Several have been sunk, and in every case excellent water has been obtained at the depth stated. Half a mile over to the west is a spring; in one of the claims water has been found. While there is no surface water at present, it is proven that the earth is full of it. Mr. Arnold, who, by the way, is the superintendent of the Roberts & Harpending Company, and a hard-working, reputable man locally, and I believe generally and especially, is now sinking a well near by, with a view to procure sufficient water for a mill. He is down less than ten feet, and has found, up to this writing, considerable water. His intention is to sink, if possible, 30 feet or more. This is the driest season; rain should commence in June. With proper effort I am confident it will cost less to supply a large population with an abundant quantity of fine water than it did in Virginia City. The San Simon River can be reached by pipes—so I am informed—at a cost not to exceed that of the White Pine Water Works. While it would be quite acceptable if the district were coursed with babbling brooks at all seasons, the scarcity of water here is no great objection.

Wood is scarce near at hand. Upon inquiry of a largely interested party of what would be the cost of wood delivered here in quantities of 1,000 cords and upward, he was frank and prompt in declaring it at not "above $20 per cord." Wood is said to be abundant not above twenty miles distant, and known to be within thirty miles. Good pine lumber is selling at 15 cents per foot. When the demand becomes large the price will be greatly reduced. For fire-wood there is an ample supply of cedar scattered about within a few miles, to last for some time, but it is too limited to be considered in making estimates for permanent supplies.

The Gila River can be reached with a railroad in forty-five to fifty miles, according to local authority. A broad, level, grassy valley intervenes. There is ample water-power, and the mountains which hug that stream above possess immense forests of superior timber. Should this immense field of ore prove half as rich as appearances indicate it will, I predict the early construction of a railway to the Gila, as a means of reaching cheap motive power and fuel. Dumps along the body of the Harpending and portions of the Brown lodes could be reached with cars at a fourth the expense it cost to reach the dumps of the Comstock.

The climate is pleasant. Days warm, but breezy and not oppressive, and nights cool. It is regarded as very healthy. There is nothing in the surroundings to change this opinion, which of course is one formed within a few months by the oldest residents. No one has consented to occupy a grave-yard yet, and therefore no cemetery is located.

Living is dear. Everything but postage-stamps sell at enormous profit, and this is so throughout all this section of country, from Fort Yuma eastward. Bacon sells at 60 to 75 cents; sugar the same; beef and mutton, 25 cents; flour, 10 cents, &c. Goods and provisions are not plenty, but so far as the assortment goes, enough for the demand. Stocks are ordered from Chicago and St. Louis via Sheridan. I am told that freight can be laid down here inside of 10 cents currency from those cities, and that a revolution in retail prices must ensue. As is always the case in new and remote places, certain lines of goods bring any price asked; as a rule, merchants' liberality seldom appears to good advantage except under sharp competition. The population is estimated in and about the mines at 300. Many are coming and going.

Little actual mining is prosecuted. Assessment work is the main business, aside from building, which is necessarily limited, although there are several comfortable houses of stone, adobe, and granite, and more building. Owing to the danger from Indians, and distance from supplies, but little is required to hold claims under the local laws.

A notice duly recorded holds six months; a shaft 5 by 5 and 6 feet deep will hold a single claim of 200 feet, or all the claims of any one company on the same lode, for one year. Men without some means should stay away until there is a demand for labor, which is very limited now, and will be for the next six months. There are men here who have bummed their way, and without the means to buy a meal or pay for recording a claim, should they find one. If they could subsist on raw quartz this would be a poor man's paradise. It is a friendly act to often warn them to stay away. The mass of the people here are unable to maintain healthy paupers, and a little starvation is good for such mendicants. Quartz operators of means ought to visit these mines. They could but be delighted to witness more good-looking ore in sight than has ever been worked in the mills in and about Virginia and Gold Hill. Veins of fine-looking ore, standing 50 feet above ground, ranging in width from 10 to 200 feet, form a prospect of enchantment to all mining enthusiasts.

As mining experts are constantly making themselves ridiculous, by giving learned opinions on mineral deposits, I shall not in the least attempt to divide the honors with them. Assays tell well for this ore; it remains for hundreds of tons to be worked in a body by mill process to establish the worth of this district.

This was written in May, 1870. Later in the year my assistant, Mr. Eilers, while in the adjoining Territory of Arizona, gathered some facts in regard to these mines the substance of which is as follows:

There is no doubt about the existence of extraordinary large quartz veins in the district, and the quantity of ore, such as it is, seems to be almost unlimited at the very surface.

In regard to the quality of the surface ore, which here, as well as in hundreds of other silver veins, will probably be found to be the best in the veins, nothing satisfactory has as yet reached me.

We are indeed informed by an article, which appeared in the Scientific Press of July 30, 1870, that a number of assays of ore brought to San Francisco yielded as follows: "$3 01, $10 37, $14 14, $18 84, $28 25, $28 35, $30 17, $43 96, $46 10, $50 23, $53 38, $55 97, $66 76, $113 13, $118 26, $130 81, $147 21, $158 03, $172 80, $224 37, $287 21, $471 24, $528 78, $561 88, $742 24, $751 87, $831 80, $1,342 50, $1,442 43, $3,038 62, $3,838 46, $4,861 09. A little gold, from a trace up to $25 22, was found in six samples." But this proves nothing. The same assays may be obtained from the smallest pocket of a silver-ore deposit. Only average samples, taken according to the methods in use in the practical working of silver ores, will reveal the true value of those veins, and that only after large amounts have been taken down.

A large number of assays, made in Arizona, of specimens taken from the ledge by one who was unacquainted with silver ores, gave less than an average of $15 per ton, and one of the original locators acknowledged to my assistant that he thought the great mass of the ores would not yield above $15 per ton, and that they all contained a high percentage of base metals. If we add to the cost of beneficiation of such ores the expense for transportation for forty-five miles by railroad to the Gila River, the as yet high cost of freight to and from the Burro Mountains, and the interest of the large capital required for starting such an enterprise, it is evident that those mines cannot be worked at a profit at present. At the same time it is clear that upon the completion of the Texas Pacific Railroad a very extensive mining industry is likely to spring up here. I learn that the attempt will be made during the next year to make at least a beginning in the development of these mines.

The Cienega mines are located about fifty miles northeast of Ralston. According to the accounts received they occur in limestone, and are rather deposits than veins. A town, named Silver City, has been located here, and some little prospecting work has been carried on, but in no case a depth exceeding 12 feet seems to have been reached on the deposits. Much high-grade chloride of silver is reported to have been found, and the principal deposits appear to lie along a zone running northeast and southwest, which is half a mile wide, and has been superficially explored for a length of three miles. Chloride district, two miles from Silver City, is spoken of in still higher terms of praise.

All these discoveries lie apparently a short distance from Fort Bayard, and may be identical with those of the Central City district mentioned in last year's report. As yet nothing definite is known in regard to them, and as no actual mining was carried on, I have not deemed it necessary to expend any means in that direction.

The passage of the Texas Pacific Railroad bill will probably exercise a powerful influence toward developing the mineral resources of southern New Mexico during the immediate future, and there are certainly no Territories which deserve more the attention of mining men than those crossed by the thirty-second parallel line.

The total white population of the mining counties of New Mexico, as given by the census of 1870, is 26,716, including Mexicans, and distributed as follows: Grant County, 1,143; Lincoln County, 1,803; Taos County, 12,079; Santa Fé County, 9,699; Colfax County, 1,992.

The gold product of the Territory for 1870 slightly exceeds $500,000.

CHAPTER IX.

COLORADO.

This Territory manifests a steady progress in the direction of settled and productive industry, and permanent public improvements of every kind. The completion of three railroads, centering at Denver, the formation of new and thriving colonies, like that of Greeley, and the growth of several branches of domestic manufactures, are all causes which, though distinct from mining, operate favorably to that interest. The absolute proximity of agriculture and mining is not always perfectly advantageous to both. Thus in California the placer-mining operations have been ruinous to large areas of farming and garden land, along the rivers below the mining ground. The vapors from smelting works are frequently injurious to crops. The high rates of miners' wages affect unfavorably the price of agricultural labor. Conflicts of interest between the two industries promote litigation while they hamper legislation. Yet, on the other hand, mining cannot maintain itself remote from auxiliaries, except at great pecuniary and social cost to the community. I regard it, therefore, as peculiarly fortunate for Colorado that within her borders mining and agriculture are "so near and yet so far;" that her rugged mountain districts are skirted with fertile plains and parks; that in days to come the camps of her pioneers will be merely outposts of her great cities. It is difficult to find an instance where the two fundamental productive activities of man are both so magnificently endowed, and so conveniently located for mutual assistance without interference.

The Territorial fair, held in September at Denver, was a striking exhibition of the wealth and progress of Colorado. It is true, it was inferior in its array of native stock to that of 1869, and no more than equal to its predecessor in point of agricultural products. But these facts have little significance. What Colorado can do in these particulars is well known already; and it matters not whether the heifers or the turnips are a few inches larger round the belly this year or last. On the other hand, the magnificent display of blooded stock in 1870 means a great deal. It shows growing wealth and intelligence among stock-raisers, and promises still better things hereafter.

The crops suffered greatly from drought, so that, although the area under cultivation was greater, the total harvest probably did not exceed that of 1869. But next season will astonish the outside world; and meanwhile, though the average yield was not realized in the present crop, the ranchmen of Colorado may claim with truth that, even under the great disadvantage of a partial failure, they far exceeded the general average of the United States.

But the great glory of the fair was its display of ores and bullion. The total value of the samples on exhibition was not far from $100,000; and the exhibition as a whole has seldom or never been equaled. The pride and joy of the citizens over this splendid testimony to their young industry is more than pardonable; it is fully justified. They have no longer any need to indulge in idle asseverations; they can point to facts.

The bullion display was very fine. There was one solid piece of gold bullion, value $39,061 65. Clear Creek County sent one silver button

weighing 1,141 pounds, value $20,000; one weighing 400 pounds, value $7,000; one 93¾ pounds, value $1,027; and one 113 pounds, value $1,625. The first two were from the Brown Company, the third from the Terrible mine and the last from 4¾ tons of Snowdrift ore.

The following is a list of the ores exhibited, together with their mill or assay values:

GILPIN COUNTY—GOLD.

Kingston lode	10 to 45 oz.	in mill	per cord.
Wautoga lode	8 do.	do.	do.
Gregory lode	6 do.	do.	do.
Bobtail lode	8 do.	do.	do.
Flack lode	10 do.	do.	do.
Stark Co. lode	6 do.	do.	do.
New Foundland lode	10 do.	do.	do.
Fairfield lode	8 do.	do.	do.
Prize lode	7 do.	do.	do.
Bates lode	10 do.	do.	do.
U. P. R. lode	10 do.	do.	do.
Delaware lode	4 do.	do.	do.
Jones lode	20 do.	do.	do.
Powabic lode	15 do.	do.	do.
Burroughs lode	8 do.	do.	do.
Yankee lode			
California lode	13 do.	do.	do.
Hidden Treasure lode	8 do.	do.	do.
Mt. Desert lode	6 do.	do.	do.
Oldorado lode			
German lode			
Emaha lode			
Kip lode	4 oz.	in mill	per cord.
Johnston lode			
Promise lode			
American Flag lode	4 do.	do.	do.
Troy lode			
Alps lode	7 do.	do.	do.
Marg't Glennan lode			
Foote & Simons lode	6 do.	do.	do.
Gunnell lode			
Winnebago lode	7 do.	do.	do.
Mammoth lode	4 do.	do.	do.
East Boston lode			
Gardiner lode	7 do.	do.	do.
St. Louis lode	6 do.	do.	do.
Peck & Thomas lode			
Baxter & Crispin lode			
Kansas lode	6 do.	do.	do.
Simmons' Fork	6 do.	do.	do.
Coaley lode, (silver)	400 do.	do.	per ton.
Gilpin lode, (silver)	300 do.	do.	do.
Pleasant View lode	10 do.	do.	per cord.
Illinois lode	6 do.	do.	do.

CLEAR CREEK COUNTY, GRIFFITH DISTRICT—SILVER ORES.

All coin values, per ton of 2,000 pounds.

Sweepstakes lode, assay	$440 00
Peruvian lode, mill run	513 80
Gilpin lode, mill run	120 00
Ni-Wot lode, assay	400 00
Griffith lode, assay	120 00
Guthrie lode, mill run	728 00
New Boston lode, assay, (50 per cent. lead)	30 00
Terrible lode, mill run	650 00
Lake Superior lode, assay	146 00
Magnet lode, mill run	320 00
Mammoth lode, assay	500 00
Brown lode, mill run	650 00
Quaker lode, mill run	200 00
Franklin lode, mill run	96 00
Astor lode, assay	400 00
Mendota lode, assay	260 00
Robert Emmett lode, mill run	179 10
Bunker Hill lode, assay	800 00
E Pluribus Unum lode, assay	1,000 00
General Jackson lode, assay	200 00
Cashier lode, mill run	230 00
Federal lode, select specimens, assay	27,000 00
Federal lode, second class, assay	800 00
O K lode, mill run	1,176 00
Dives lode, assay	646 00
Silver Plume lode, lot of 500 pounds, assay	2,535 00
Snowdrift lode, lot of 300 pounds, assay	3,356 00
Snowdrift lode, lot of 100 pounds, assay	3,159 00
Snowdrift lode, lot of 100 pounds galena, assay	1,404 00

ARGENTINE DISTRICT.

Stevens' lode, mill run, (65 per cent. lead)	260 00
Paymaster lode, assay, (80 per cent. lead)	84 50
Baker lode, mill run	120 00

DAILEY DISTRICT.

Mountain Ram lode, assay	444 60

UPPER UNION DISTRICT—GOLD.

Silver Mountain lode, mill run	$100 00
Conqueror lode, mill run	125 00

MONTANA DISTRICT—SILVER.

Commonwealth lode, assay, (lead 60 per cent.)	30 00
Congress lode, assay	240 00
Highland lode, assay	200 00
Capital lode, assay	240 00

MORRIS DISTRICT.

Massachusetts lode, value unknown.

LINCOLN DISTRICT.

Blazing Star lode—	
Surface, assay, gold	8 26
Surface, assay, silver	158 34
Sixty-five feet deep, assay, gold	74 82
Sixty-five feet deep, assay, silver	633 33
And 13 per cent. copper.	

IDAHO DISTRICT.

Seaton lode, silver, mass of 455 pounds, mill run	300 00
Schaffter lode, native gold, specimens, value unknown.	

Of course these figures do not represent the average yield of the ores treated, still less the average value of the vein-material. Nor would the true average mill-yield give a direct measure of the general quality of ore. A common error with American miners has been the habitual, though often innocent, exaggeration of the "average value" of ores. People do not seem to know what this phrase means. At first it used to mean the average result of a large number of sample assays; then, when we had grown wiser, it meant the average of pulp assays taken in the mills; and beyond the latter signification we have apparently not yet advanced.

Now any district can maintain a high "average value" of this sort, as long as it sends only good ores to the mill or furnace; and the figures signify, *not* the average value of all the ore in the veins, not even that of the ore extracted, but that of the ore treated. In other words, they are a criterion of the expense of mining and reduction, and that is all. Moreover, since no mines ever did or do contain rich ores only, the high yields are generally associated with wasteful sorting, which still further increases the expense of mining.

Let him who would apply this test to a mine or a district measure the excavations on the lodes, calculate the whole amount of vein-matter removed, and compare this with the total of bullion produced. In Colorado this style of calculation would produce some surprising results. But Colorado is no worse and no better than any other districts in this respect. She is just now working her best mines, and of these only the best and second-best ores. When, in the progress of healthful industry, more mines shall be opened, existing mines operated on a larger scale and more permanent system, and less ore thrown away or left standing as too poor to work, we shall see an apparent decrease in the value per ton of the contents of her veins; and I cannot wish her better fortune than just this decrease.

In a subsequent chapter the processes of reduction employed in Colorado will be fully discussed, and more exact information as to average value and yield will be given.

BULLION PRODUCT OF 1870.

The Denver News estimates the total gold and silver yield of the Territory for 1870, as follows:

Shipped by express	$2,400,000
Add ten per cent. for actual value	240,000
In private hands from Denver	500,000
Shipments of matte	884,000
Shipments of Terrible ore	176,000
Other concentrated ores	300,000
From southern mines	100,000
From northern mines	150,000
Used by manufacturers	120,000
Total coin value	4,870,000
Add 12 per cent. premium	584,400
Total currency value	5,454,400

I am obliged to regard this estimate as altogether too high. The article which contained it showed the manner in which each item was calculated; and a revision of the whole, with additional sources of information, for which I am indebted to Mr. Schirmer of the Denver mint, and Mr. Jones, agent of Wells, Fargo & Co. at that place, leads me to substitute the following estimate, as the most accurate which I can obtain:

Shipped by express	$2,160,000
In private hands from Denver	120,000
Shipments of matte, (Professor Hill)	884,000
Terrible ore	176,000
Other ore	110,000
Shipments from southern mines	100,000
Shipments from northern mines	50,000
Used by manufacturers	75,000
Total coin value	3,675,000

The items of northern and southern mines in these estimates refer to the fact that much of the gold gathered in the mines of Park, Lake, and Summit Counties goes out, by the way of Colorado and Cañon Cities, to Pueblo, and thence east without coming to Denver at all. So of the product of the North Park, Snake, and White River mines in Northern and Northwestern Colorado. It finds its way to the line of the Union Pacific Railroad and thence east or west.

The deposits at the Denver branch mint were as follows:

DENVER BRANCH MINT.

Month.	No. of deposits.	Value.
January	63	$49,900 10
February	76	58,814 93
March	65	48,801 08
April	82	48,170 79
May	162	76,036 30
June	234	99,474 77
July	247	108,210 78
August	254	119,565 22
September	222	160,358 96
October	194	91,752 02
November	130	53,816 27
December	97	52,546 68
Total	1,826	967,447 90

In the last six months of the year there were 1,144 deposits, of the value of $586,249 93, showing a very gratifying increase in both number and amount.

The following altitudes of noted localities, mostly within the Territory of Colorado, are taken from a pamphlet published by Colonel Baker of Central City. There are differences of a few feet in the determinations of many of these points. Thus, Denver, according to another good authority, has an altitude of 5,387 feet, which may easily be accounted for by supposing the observation to have been taken on the higher part of the town. Since, a third determination, made on the lower bottom of the Platte, at Denver, near the mouth of Cherry Creek, gives 5,303 feet only. Again, Georgetown is sometimes placed at 8,906 feet, a serious difference; and the Berthoud Pass at 11,562 feet, or 213 feet higher than in the table below. In a number of instances, Frémont's original hypsometrical determinations are given for comparison with more modern ones.

1. WESTERN PLAINS.

	Feet.
Omaha, (library and state-house)	1,211
Julesburg, eight feet above river	3,703
Denver	5,317

2. BASE OF MOUNTAINS.

Franklin, (St. Vrain's)	5,256
Boulder City	5,536
Golden City	5,882
Golden Gate	6,226
Mt. Vernon	6,479
Soda Springs, (Pike's Peak)	6,515
Colorado City, 15 feet above water	6,342
Divide between Arkansas and Platte, on road from Colorado City to Denver	7,554

3. EASTERN SLOPE OF MOUNTAINS, UPPER PLATEAU.

Central City	8,300
Gold Hill	8,636
Osborn's Lake, (Ward district)	8,821
Bergen's Ranch	7,752
North branch of South Platte, Denver and Buckskin road	8,028
Lake where Denver road enters South Park	10,041
Jefferson, (South Park)	9,842
Tarryall, (South Park)	9,932
Forty-six miles below Tarryall, on the Platte	8,151
Where the Tarryall road leaves or strikes Fontaine qui Bouille	8,273
Three miles lower down	7,794
Junction, North and South Clear Creeks	7,086
Idaho, (12 feet above South Clear Creek)	7,800
Head of Virginia Cañon	9,690
Consolidated Ditch Office, (Missouri City)	9,073
Mouth of Fall River	7,930
Level of Clear Creek at Empire City	8,583
Base of Berthoud's Pass	9,464
Georgetown	8,452

4. PASSES.

Georgia Pass, (South to Middle Park)	11,487
Berthoud's Pass, (Clear Creek to head of Middle Park)	11,349
Same, (General Case)	11,371
Ute Pass, (Frémont)	11,200

5. ALPINE SUMMITS.

Mt. Audubon, (southeast of Long's Peak)	13,402
Velie's Peak, (northwest of Long's Peak)	13,456
Long's Peak, (approximately)	14,056
Mt. Guyot, (west of Georgia Pass)	13,223

	Feet.
Pike's Peak	14,216
Pike's Peak, (Frémont)	14,300
Gray's Peak, (Argentine district)	14,251
Parry's Peak, (northwest of Empire City, named by General Case)	13,133
Mt. Flora, (a detached peak east of Parry's Peak)	12,878

6. MIDDLE PARK.

Three-fourths of a mile from summit of Berthoud's Pass, (western slope)	10,696
Head of Middle Park	8,690
Hot Springs of Grand River, 25 miles from head of Park	7,725

7. TIMBER LINE.

North slope of Pike's Peak	12,043
On the range of Berthoud's Pass	11,816
Eastern slope of ridge leading to Gray's Peak	11,643
Eastern slope of Mt. Engelmann	11,578
Southern slope of Mt. Flora	11,807
On Snowy Range	11,700 to 11,800
Mt. Audubon	11,300
Long's Peak	10,800
Wind River Mountains	10,160

These formidable altitudes are indications of the difficulty of intercommunication between the different mining districts. Yet the enterprise and skill of American engineers are not to be baffled by such obstacles; and it is safe to predict that railway communication, in some form, will, ere long, be extended into the heart of the mountains, to say nothing of the plans of sanguine projectors, who talk already of penetrating, by this line, to the Salt Lake Valley itself. At present there are three railroads centering at Denver: the Kansas Pacific, coming from Kansas City, the Denver Pacific, connecting with the Union Pacific at Cheyenne, and the Colorado Central, which strikes from Denver into the mountains. The latter road has been completed to Golden City, a distance of about fifteen miles, and was opened for business with appropriate festivities on the 24th of September, 1870. Another road, called the Boulder Valley Railroad, is in process of construction from a point on the Denver Pacific, about twenty-five miles north of Denver, to the Boulder coal-fields.

It is proposed to continue the Colorado Central to Central City or Georgetown, and some preliminary work has been done in Clear Creek Cañon. But the question of gauge, which has been considerably discussed, still remains unsettled. The narrow gauge, which has been employed with excellent economical results in India, Canada, Norway, and elsewhere, would be, it seems to me, just the thing for mountain branch roads, on account of its superior cheapness in construction and operation; but it appears difficult for the Colorado people to give up the idea of a great transcontinental trunk-line. The ambition of the powerful Kansas Pacific Company seems to point in this direction. A narrow-gauge line beyond Golden City, necessitating transshipments at that place, would be a great local advantage to it, while the continuance of the ordinary gauge to Central and Georgetown would be better for those localities, if its construction and successful operation were feasible. My impression is that Gilpin and Clear Creek Counties will have to choose between the narrow gauge and nothing. Meanwhile, a bold and, perhaps, visionary scheme is said to be connected with the Boulder Valley line. I quote the following statement from a letter to the New York Tribune:

The Kansas Pacific is a powerful corporation, and, properly, it is the line by which the Cotton States are to communicate with California and China; but, unfortunately,

it becomes tributary to the Union Pacific at Cheyenne, while it traverses a treeless, houseless prairie of nearly five hundred miles east of Denver. Engineers have been struggling for a passage through the Arkansas Cañon; thence through the Poncho Pass into San Luis Valley, and they have tried other routes, though they knew that if they succeeded they would find beyond the eastern slope of the Rocky Mountains an uninhabitable country, more than one thousand miles wide. The present move would seem to be toward Cariboo, in the building of the Boulder Valley Road, that coal may first be obtained, and then that the mining region may be reached before the Union Pacific should consider whether the prize is worth seeking. But there is more than this still behind. Boulder Pass is between Cariboo and Central, and here the snowy range crowds so far to the east that it is but a few miles through to the head-waters of the Colorado of the West, whence a passage into Salt Lake Valley will be easy. When this shall be accomplished a grand scheme will be developed. The Central Pacific, which meets the Union Pacific at Ogden, seven hundred and fifty miles east of Sacramento, will clasp hands with the Kansas Pacific, and the Union Pacific will see passengers and freight take this new route, which is said to be one hundred and fifty miles nearer to New York.

Leaving these pictures of extensive possibilities, it is well to return to the immediate needs of the principal mining districts of the Territory; and these, I do not hesitate to say, will be best, since most speedily, served by the construction of narrow-gauge railways. In a subsequent chapter of this report some further information on the subject will be given.

The erection of smelting-works for the treatment of Colorado ores is a matter closely connected with the question of railway transportation; and the public spirit, outrunning, as usual, the actual progress of industry, has projected such works in numerous localities. An establishment of the kind is erecting at Omaha, under the charge of Mr. Balbach, of the Newark (New Jersey) Works, and there has been much talk and some action concerning similar enterprises at Chicago, St. Louis, and Kansas City. It is also proposed to establish works on the Union Pacific, among the Wyoming coal-fields, and at Golden City, or somewhere else at the base of the mountains, among the Colorado coal-fields. The relative natural and commercial advantages of all these localities have been subjects of lively discussion; but I fear that the full relations of the subject have been but partially investigated. Letters are frequently addressed to me as commissioner, requesting my opinion whether this or that town "would be a good place for smelting works," as if general opinions on such a point could be proper bases of action. I can only say, in general, that the most thorough and elaborate preliminary estimates as to the cost of construction and operation, the character and amount of the certain supply of ores, and the margin of profit in their treatment, are of course indispensable. But after all these have been obtained, the assurance of success is not complete. The multiplication of smelting works and the limited supply of ores, so far as Colorado is concerned, will bring about a fierce competition, in which natural advantages, and even metallurgical skill, may go down before heavier capital and shrewder business management. The production of the mines may be gradually stimulated by the increased facilities of reduction; but this cannot have an immediate effect, and meanwhile financial strength, the ability to pay high cash prices for ores, and—what is more important—the ability to stop and stand still when prices do not permit profitable work, will give decisive advantages to some works, while others, less fortunate in these respects, are forced to follow the lead of rivals, putting prices up or down to get business, not daring to suspend operations, lest the suspension should be final, yet finding it equally ruinous to go on. I have seen this drama played repeatedly, till the curtain fell upon a sheriff's sale.

The success of smelting-works at a distance from the mining districts,

depends moreover upon the good will of the railroad companies, who may favor one or another locality in the prices of transportation. The question of establishing such works at points near the Rocky Mountain coal-beds is affected directly by the metallurgical value of the coal—a matter which needs more thorough and extensive study than it has yet received.

Again, smelting-works at accessible commercial centers, drawing their supplies from many different quarters, have a great advantage over those which depend directly upon single districts; yet this advantage may be neutralized by some of the causes enumerated above, or in the course of time by the establishment of other works, intercepting in detail the supplies from each quarter. Thus the extensive works of Swansea in Wales possess a commercial supremacy, long established and acknowledged, but precarious in its particular elements.

It is, therefore, impossible to predict which works of the many now projected east of the Rocky Mountains will survive and flourish. I refer in this connection to enterprises which are expected to be permanent. There are numerous small establishments springing up from time to time in connection with the discoveries of productive mines, paying for themselves in a few months, and dying when the mines, even temporarily, give out. They belong commercially in the same category as stamp-mills.

GILPIN COUNTY.

The stamp-mills of Gilpin County, old and new, number about seventy, with more than 1,300 stamps. Probably half this number of stamps have been in operation more or less steadily during the year, crushing about 100,000 tons of quartz, with an average yield of $12 to $15 per ton. The average number of stamps running throughout the year was about 400. A large portion of the rock crushed was custom-rock. Some of the most productive mines were closed for months on account of quarrels between companies. Among the lodes which have been worked with more or less steadiness are the Fiske, Milwaukee, the California and its extension, the Gardiner, the Roderic Dhu, Kansas, Camp Grove, Flack, Prize, Sudeburg, Jones, Fairfield, Kent County, Bobtail, Burroughs, and Gregory. The Coaley mine at Black Hawk, the only silver mine worked, so far as I know, in that vicinity, produced some $20,000 of silver during the first half of the year.

The bullion shipment from Gilpin County (gold) for the year ending July 1, 1870, was as follows:

	Coin value.		Coin value.
July	$124,000	February	$107,000
August	161,500	March	114,000
September	122,000	April	78,000
October	110,000	May	112,500
November	120,500	June	116,100
December	106,500		
January	106,000	Total for the year	1,378,100

The bullion shipments for the twelve months previous to July 1, 1869, coin value, were $1,267,900.

In December, 1870, the following mills were running in Gilpin County, mainly on custom-rock, or under lease. It will be seen that the number of stamps in operation is very high for the season, and above the average for the year, an encouraging fact.

It is an illustration of the incompleteness of the first returns furnished

by the assistant marshals under the census law, that the total production of stamp-mills reported to the Census Bureau from Gilpin County for the year ending June 1, 1870, was but $486,429, or about three-tenths of the actual shipments of gold for the same period.

No.	Name of mill.	No. of stamps.
	BLACK HAWK.	
1	Sensenderfer	20
2	Holbrook	10
3	University	15
4	Fullerton and Kimber's	15
5	Meade's	20
6	Lake's, (Bobtail)	12
7	North Star	25
8	Miller and Borum's	10
9	Fitzpatrick's	10
10	Lewis's	12
11	Black Hawk	60
12	Consolidated Gregory	23
13	Dickinson's	20
14	New York	55
	CENTRAL.	
15	Lexington	22
16	Barrett's	30
	NEVADA AND EUREKA GULCH.	
17	Waterman's Eureka	15
18	Kansas-Colorado	12
19	Potter and Hawley's	15
20	Beverley's	12
21	Clayton's	12
22	Hardesty	25
23	Philadelphia	25
	Total number of stamps	477

In addition to these there were several other mills, unknown to me by name, raising the aggregate number of stamps to more than 500.

In view of the limited extent of the productive gold-district of Gilpin County, the number of stamps which it keeps in operation is unequaled, except by the Comstock Silver district, in the history of American mining. But this number would be much greater under a proper system of mine ownership and management. I take from a pamphlet by Colonel G. W. Baker the following statement, showing how the most celebrated lodes of Gilpin County are subdivided among different owners. The table suits my purpose all the better, because it was not published in condemnation of this system, but to show how many companies had failed to develop their mines successfully, even upon veins of acknowledged value. I quote it to prove that the great number of these companies was one of the principal causes of failure.*

* The subdivisions of some of these lodes are given differently by Professor Hague, whose account is quoted below. I am not able to explain the discrepancy.—R. W. R.

The Gregory lode and its extension are divided among the following companies:

	Feet.		Feet.
Black Hawk	500	Briggs	250
Consolidated Gregory	500	Smith and Parmelee	1,100
Narragansett	400	New York	250
Rocky Mountain	200	United States	400
Benton	600		
Russell	300	Aggregate	4,500

This is considerably more than the known length of the lode. So much the worse for the remoter claims. The shafts sunk upon this lode and its extensions have an aggregate depth of between 5,000 and 6,000 feet, some of them being 500 feet deep. Certainly half this amount of shafting has been required by the divided ownership merely. The vein could have been equally well developed without it.

On the Mammoth lode we have:

	Feet.
Private owners	1,280
Jerome Riggs & Co	200
National Company	233
Gold Rock	260
Mammoth Company	300
Black Hawk Company	400

Aggregate length between 3,000 and 3,500.

Aggregate of shafting about 1,600.

The Bobtail load is divided among—

	Feet,
Bobtail Company	433⅓
Sterling Company	66⅔
Brastow Company	62⅔
Sensenderfer Company	128
Private owners	33⅓

Length between 700 and 800 feet.

Shafts will aggregate nearly 3,000 feet. Many of them 400 feet deep and over.

The Gunnel lode:

	Feet.
Gunnell Company	450
Central Company	200
University Company	266
Cook Company	66
Gunnell Central Company	195

Remainder owned by individuals.

Aggregate over 1,200 feet.

Shafting will aggregate over 2,000 feet.

Development over 400 feet.

The Burroughs lode:

	Feet.
Ophir Company	462
Gilpin Company	262½
Colorado Company	200
Burroughs Company	255

	Feet.
Cooper Company	50
Hardesty Company	265
Pacific National (Branch)	550
First National Company	600
Gold Hill Company	70
Baltimore and Colorado Company	40
Quartz Hill Company	30

Aggregate length over 3,000 feet.
Aggregate of shafting over 5,000 feet.
Developed between 400 and 500 feet.

The Bates lode:

Rocky Mountain Company	250
Bates & Baxter Company	300
Union Company	200
Loker Company	400
Gregory Company	100
Private owners	300

Aggregate length 1,500 to 1,600 feet.
Shafts aggregate in depth at least 2,000 feet.

The following companies own fractions of the lodes placed opposite their names:

Companies.	Lodes.
American Flag	American Flag.
Kansas	Kansas, Camp Grove, Sullivan-Gardner, Cook County, Cooper.
Egyptian	Egyptian, Massachusetts.
Topeka	Topeka.
Alps	Alps, Mackie.
Nottoway	Nottoway.
King	King, Golden Wedge, Dorchester.
Rochdale	Harsh, Calhoun, Wood.
Prometheus	Prometheus.
Empire	Empire, American Flag Ex.
Monitor	Canton, Pennsylvania.
Keystone	Calhoun, Wood, Cisler, Rockford.
Philadelphia & Colorado	Clark-Gardner, Gardner.
Clark-Gardner	Gardner.
Congress	Saratoga.
Private	Illinois.
Ford	Jefferson, Goldsborrow.
Hill	Fairfield.
Fairfield	Fairfield, Leavenworth.
Kershaw	Bench, Tuscola.
Private	Pewabic, Kingston, &c.
Montana	Kansas, Kent County, Illinois.
Manhattan	Fisk, Gregory, Ex. Tucker, Ground Hog, Bobtail, Enterprise, Cotton, Kip, Galena.
Rocky Mountain	Bates and others.
Standard	Fisk and others.
Alliance	Harsh, Crawford County, Carolton, Huber, Stump Coin, Berry, Alliance.
Corydon	Corydon, Newfoundland, Lyman, Excelsior.
Lone Star	Pacific, Metropolitan, Atlantic.
Columbia	Wall Street.
Thurber	Grace, Burton.

Companies.	Lodes.
Whipple	Bobtail, Fisk.
New England	Running.
Fisk	Fisk, Running.
Jacques	Mercer County.
Sierra Madre	Eureka.
Eureka	Eureka.
Chicago	Kansas, Monroe.
Morrell	Morrell.
Merchants	Senator, Merchant, Commercial, Oscar.
Fisher	Wood, Calhoun.
Chase	S. P. Chase.
United States	Gregory, 2d Gregory Ex.
Josephine	Grant, Josephine, German, Peck & Thomas, Ogden.
Susquehanna	German.
Rochester	Burton, Rhoderick Dhu.
Great Eastern	Hoosier.
Commonwealth	Prize.
Crozier	Mitchell, DesMoines, Perrin, Freeland.
Empire	Foote and Simmons.
Loker	Bates.

It is difficult to see how properties so scattered and divided could be successfully administered. The smallness of the claims becomes, of course, most inconvenient and injurious when they are worked with vigor. The prosecution of active and productive mining rapidly exhausts the ground on the one hand, and leads, on the other, to conflicts and interferences with neighboring claimants, with regard to dumps, right of way, drainage, trespasses, etc. Hence it is the leading companies which have been most damaged by the original folly of excessive subdivision of the lodes. There is no cure for the evil but consolidation of adjacent properties; and this is retarded by the inflated capital as well as the passions or exorbitant demands of the different owners. But come it must.

From the careful chapter of Professor J. D. Hague, (United States Geological Explorration of the Fortieth Parallel, Vol. III,) on the gold veins of Gilpin County, the following accounts of some of the representative lodes and mines have been extracted and condensed:

The most important and best developed lodes are grouped about Central City within a circle two or three miles in diameter. Concerning these lodes in general, it may be said that they are all inclosed in rock of one common type, chiefly granitic, with some gneissic varieties. Their course, with few exceptions, is between due east and west, and northeast and southwest. The prevailing course is 5° to 10° north of east. Examples are the Bobtail, Burroughs, Gardner, Flack, Gunnell, Winnebago, and many others. Exceptions are the Gregory, Bates, and a few others. The dip usually approaches the vertical. The lodes possess the features of fissure veins, but are remarkably free from faults or displacements.

The Bobtail lode has the reputation of having been the most productive vein of Colorado, and of still yielding the richest gold ores. It crops out on the northern slope of Bobtail Hill, not far below the crest, and several hundred feet above the base. This hill is on the south side of Gregory Gulch, about half way between Central City and Black Hawk. Gregory Hill is west of it, beyond a shallow ravine. The western end of what is commonly called the Bobtail lode is at or near this ravine; and the vein is traced thence easterly about 800 feet along the steep side of the hill. It is one of a group, comprising the Bobtail, Fisk, Gregory, and Bates, the courses of which appear to converge westwards, so that, if continuous, they probably intersect or join the Mammoth, a large vein farther west, coinciding closely in course and dip with the Bobtail. This relation is not clearly exposed, but seems probable. The Bobtail is considered by many a continuation of the Mammoth, faulted perhaps a hundred feet, near the ravine between Gregory and Bobtail hills. In the absence of a continuous outcrop the name

Whi
New
Fisk
Jacq
Sierr
Eure
Chic
Morr
Merc
Fish
Chas
Unit
Jose

Susq
Rocl
Grea
Com
Croz
Emp
Lok

It
suc
cou
vig
hau
and
rigl
nie
sub
tior
as
But
E
Gec
veil
ati

T
a ci
said
gne
and
amp
oth
pro
bly
T
rad
Bob
hill
Bla
of v
tra
gro
to c
mo
Thi
r

Bobtail is definitely applied to the lode east of the ravine. Its average course for 800 feet is north 75° east, magnetic, or, allowing 15° for variation, true east and west. Its dip is almost vertical, varying slightly at different points to north or south. The width varies from a few inches, or a well seam, to 10 or even 15 feet, not exceeding in the average 3 or 4 feet. The country rock may be generally described as gneiss, though sometimes distinctly granitic in character. It possesses the common characteristics of the probably metamorphic rock that prevails throughout the more elevated portion of the range. It frequently shows a thinly-banded structure with an easterly dip. The walls of the vein are usually pretty well defined, particularly the south wall, which is almost always easily followed, and carries in most places a thin clay selvedge or parting. The north wall appears less regular, and is sometimes difficult to distinguish. The vein-matter is a highly siliceous feldspathic mixture, carrying much free quartz, but not presenting the usual appearance of solid quartz veins. In many places, even where the vein is wide and well defined, the filling has a granitic look, differing but little from that of the country rock; and usually in such cases it is quite as barren. The gangue accompanying the ore is a soft-whitish or pale-greenish rock, consisting chiefly of decomposed or altered feldspathic material, mixed with quartz, and thickly impregnated with iron and copper pyrites, usually in small crystals. The richer ore is concentrated in a seam of solid sulphurets, consisting mainly of iron and copper pyrites, intimately mingled with which are comparatively small quantities of galena, zinc-blende, arsenical pyrites, and other allied minerals. Gold, rarely or never entirely without silver, is associated with the pyrites. Usually the fine copper pyrites is the richest in gold; the iron pyrites, when fine and close-grained, is also a rich gold-bearing ore, but when coarse-grained and distinctly crystalline, it has much lower value.

The productive portions of the vein usually carry a seam of the solid, gold-bearing pyrites, varying in width from an inch or two to two or three feet. An average width of ten or twelve inches is deemed an excellent vein of pay-ore. This seam of pyrites is usually accompanied by a mass of vein-matter or gangue, from one to three or four feet in width, which carries the finely-crystallized sulphurets, generally disseminated through it, as already described. These two methods of occurrence of the ore furnish two qualities for treatment; the last named, that which fills the greater part of the vein, affording stamp-rock that yields about an ounce of retorted amalgam, or $16 50 to $18, coin, per ton; the former, or the concentrated seam of pyrites, affording the first-class or smelting ore, assaying from three to twelve, and averaging about six ounces of fine gold and six ounces of fine silver per ton, besides the copper, which, when saved in the smelting process, forms an important element of its value.

The distribution of ore in the vein is not uniform. Some portions of the ground, for considerable distances, both horizontally and vertically, are barren; the walls approach each other; the vein-matter pinches out, or sometimes, the vein, where preserving its width, is filled with barren rock. In some places the fissure is filled with a good vein of stamp-rock, with little or no first-class ore; in others the solid seams of sulphurets, the copper and iron pyrites, attain and preserve for considerable distances, a width of two feet or more. Commonly, however, as has just been stated, the vein, where productive, consists of a seam of gold-bearing pyrites eight or twelve inches in width, with an accompanying belt of pay-ground, having the ore more or less liberally distributed through it, and affording stamp-rock of fair quality. The average yield of the stamp-rock of this lode is six or seven ounces of retorted amalgam per cord of ore. The ounce of amalgam is worth from $16 50 to $18, coin. The cord contains from seven to eight tons. The yield is accordingly about $14 or $16, coin, per ton.

As nearly as could be ascertained from the officers of the Bobtail mine, working on the western portion of the lode, the proportion of first-class ore to the second-class or stamp-rock was about one-tenth; while the whole amount of ore of the two grades was estimated to be from one-third to one-half of all the rock raised from the mine.

The lode is clearly traced and is developed for 800 feet in length. Unfortunately that extent of ground, itself not more than enough for one well-managed mine, is divided up into six independent claims, some of them very short, not only increasing greatly the costs of superintendence and general management, but presenting great hinderances to the economical opening and working of the ground. These claims, beginning at the west end in the ravine and proceeding easterly, are as follows:

	Feet.
The Bobtail Gold Mining Company owning	433⅓
The Sterling Gold Mining Company owning	66⅔
The Black Hawk Gold Mining Company owning	72
The Field Gold Mining Company owning	33⅓
The Trust Gold Mining Company owning	66⅔
The Sensenderfer Gold Mining Company owning	128
	800

The development of these claims has reached an average depth of about 500 feet. They have been worked independently of each other except in the matter of drainage, which has been effected by pumping machinery owned and operated by the several parties on joint account. But the very limited extent of most of the claims has been the cause of very irregular work below ground, especially in those east of the Bobtail Company. Each claim, even the shortest, has carried on its operations through an independent shaft, usually stoping the ore underhand as fast as made accessible by the shaft. No systematic opening of the ground, in advance of the stopes, or economical or advantageous methods of attacking or handling the rock can be employed under such conditions. The vein is not wide, and the rock is hard, making the costs of sinking and stoping very considerable; water is abundant and its removal involves much expense; nor is the vein uniformly productive. All these qualities demand economy and a well-organized and comprehensive system of management as the first condition of permanent and successful mining. In the absence of this the profits are likely to be absorbed by the multiplied costs of administration when the lode is productive, and when the lode becomes poor, in any given portion, the work is liable to be abandoned by the parties that are most affected, and only resumed when the neighboring claims have afford renewed encouragement.

The Bobtail lode has been remarkably productive and has yielded very rich ores, so that, in spite of all the existing disadvantages, it has during its history paid large profits to its owners. Nevertheless, its operations of late have been less prosperous. Some of the shorter claims under temporary discouragements stopped work two or three years ago; the others, owing to various causes, of which the inefficiency of the pumping apparatus has been an important one, and the necessity of investing largely in machinery and other improvements another, have been unable for some time to make any dividends; and, in the summer of 1869, all work on the lode was suspended awaiting the result of negotiations then in progress, having in view the consolidation of the various companies interested in the property.

The first of the above-named companies, the "Bobtail," owns more than one-half of the developed portion of the lode. The upper portion of the ground is said to have been worked in early days by various parties, who gouged out what they could without method or regard for the future, and although it yielded largely in rich ores, the present company, working the mine since 1864, have not only encountered a good deal of poor ground, but have been obliged to spend much money and patient effort in providing proper machinery and getting the mine into a suitable condition for economical operation. It was originally opened by several vertical shafts, two of which have been continued by the present company, and are now connected with an incline, through which all the ore is hoisted to the surface.

The eastern part of the ground is better than that further west, and has therefore been more extensively worked. When visited by Professor Hague there was a good vein of smelting ore in this part of the mine, varying from 12 to 18 inches in width, accompanied by about 24 inches of fair milling ore. Tho upper part of the mine is pretty thoroughly worked out, but the deeper portion has been opened by levels, making the ground available for back stoping. As this had been done only to a limited extent the force that could be employed in producing ore was not large. During the season previous to closing the mine its average product was 240 or 250 tons of milling ore per month, yielding about $15, in coin, per ton, besides which, during the foregoing year, some 20 tons per month of first-class ore had been sold at the smelting works, at an average price of little less than $70 per ton, in currency.

Next east of the Bobtail Company's mine is that of the Sterling, owning 66 feet. This claim is opened by a vertical shaft which has reached the greatest absolute depth of any on the lode, and was used by the Drainage Company as a pump-shaft. The mine has been worked out above, but when seen by Professor Hague, previous to the suspension of work, there was a very good vein in the bottom, carrying a seam of compact iron and copper pyrites, a foot or more in width, besides a belt of stamp-rock of good quality. The ores are essentially of the same character as those of the neighboring mine just described. During the year previous to closing the mine something over 150 tons of smelting ore had been sold at the Smelting Works, on which the mine realized about $90 per ton, in currency, its average tenor being about six ounces of fine gold and six or seven ounces of fine silver to the ton. The mine has good ground, but it is too short in extent to be worked advantageously.

The pump of the Drainage Company, established in the Sterling shaft, consists of a 10-inch force-pump, or plunger, which is placed about 250 feet below the adit-level; this level, 130 feet below the mouth of the shaft, passes through the mine of the Bobtail Company, as may be seen in the section, and delivers the water in the ravine, west of the Bobtail works. Below the plunger-pump is a draw-lift of 12 inches diameter, raising the water from the bottom of the mine to the cistern supplying the force-pump. The column above the plunger is a 10-inch pipe, except where, for want of a sufficient supply of the latter, two 6-inch pipes are introduced as a substitute.

The pump was worked by the engine on the Black Hawk property, the power being

transmitted by a line-shaft and thence by belting to the pump-gearing. The inefficiency of this apparatus has been the cause of great hinderance to the several mines dependent upon it, especially as most of them are almost as deep as the pump-shaft and are frequently obliged to suspend operations altogether on account of water. The pump, while running, worked on a six-foot stroke, making from seven to ten strokes per minute, and was obliged to run night and day steadily.

An intimate connection between this lode and the neighboring lodes, the Fiske and Gregory, is said to be shown by the drainage; the last-named, when worked to a deeper level than the Bobtail, having drained the latter completely; while under reversed conditions, the Bobtail drained both the Fiske and Gregory. The Running lode, opened a half mile east of the mines on the Bobtail, and regarded by some as a continuation of the same, and by others as a separate lode, is said likewise to be drained by the Bobtail pump. Nevertheless the west shaft of the Bobtail mine is filled with water some 40 or 50 feet above the bottom of the pump-shaft. With regard to this it is stated that the shaft was perfectly drained, until, in sinking, a large stream of water was cut, driving the men out and filling the shaft; and on being suffered to stand in that condition for a season, the crevices and clefts about the bottom of the shaft, formerly affording passage to the water, may have become choked with clay and thus impenetrable.

The next two claims on the east, the Black Hawk and the Field, have been worked to a depth of about 400 feet, and have been very productive, especially, it is said, the latter.

The Trust mine, claiming 66⅔ feet, next east of the Field, has been worked to a depth of about 540 feet or little more. Nearly all the productive ground has been worked out to within a few feet of the bottom, where the vein, at the depth just mentioned, was four or five feet wide, with two feet of pay-ground.

The next claim, and the eastern limit of the developed portion of the lode, is the Sensenderfer. This mine has the enviable reputation of having not only the richest ore, but the most uniformly productive ground, of all the claims on the vein. It is worked by means of two shafts to a depth of more than 500 feet, and although pretty much worked out above, the bottom of the mine, when work was suspended, showed a strong vein, two feet wide, filled with ore of high grade. During several years this claim was worked by Mr. John Sensenderfer, who is reputed to have taken from it a large amount of gold. It has also been idle for various reasons during much of the time since its first discovery. Since 1866, it has been worked by a company, consisting chiefly of a few gentlemen residing in Central City, and during that time has been one of the most profitable enterprises in the Territory. The entire product of ore was usually sent to the stamping mill without selection of first-class for smelting, and yielded on the average 15 ounces of gold to the cord of rock, or two ounces per ton. In some cases three or four ounces per ton were obtained.

Late in the summer of 1868 the company began to select the best of their ore for smelting, in order to avoid the loss involved in treating ores of so high a value by the ordinary stamping process.

During the two years ending September 1, 1868, the total product of this claim was, in currency		$197,155
Of which the costs of production were—		
For mining, 600 cords, say 4,500 to 4,800 tons	$51,089	
For milling, 600 cords, say 4,500 to 4,800 tons	26,846	
		77,935
Leaving as profits, currency		119,220

Out of these profits ten dividends of $10,000 each were paid previous to November, 1867; during the succeeding year no dividends were paid, as the mine not only required considerable outlay for improvements, but suffered much delay and embarrassment on account of water. In the summer of 1868, however, the work was going on profitably.

During the month of August of that year, which may serve as an average, the costs were stated as follows:

Ordinary mining expenses, in currency	$2,600
Proportion of pumping costs	800
Hauling ore to mill, 30 cords, at $11	330
Milling costs	700
	4,430

Costs, per cord, $147 66, or about $18 50 per ton of ore, in currency. Of the above quantity of ore the yield at the usual average rate of 15 ounces of retorted amalgam, per cord, would be 450 ounces for 30 cords, which at $20, currency, per ounce, would

be $9,000, leaving a profit of $4,570. The mine is provided with hoisting power, a small engine driving a simple winding-spool by means of a pulley and belt.

The total yield of the Bobtail lode since the date of its discovery is said, by those who have the best means of information, to be $2,500,000; but it has been worked by so many different parties, and in such an irregular manner, that in the absence of reliable records it is impossible to arrive at anything nearer than a rough estimate of the product.

The Fiske lode is on Bobtail Hill, a little north of the lode just described, and having such a course, as may be seen on the map, that the two veins should intersect each other in the ravine, a little west of the Bobtail Mine. This lode is said to have been worked with encouraging results in times past.

The Gregory lode, is, perhaps, the most widely celebrated in the Territory. During the ten years that have passed since the commencement of work on this lode, it has been the scene of active mining operations, and is at present unequaled by any other in the region as regards the general extent of its development; the registered locations on it covering about 4,000 feet, of which nearly half is worked to a depth of about 500 feet.

While the Bobtail may be looked upon as a continuation of the Mammoth, either direct or slightly displaced, the course of the Gregory diverges from the latter at an angle of about 45°. Its point of divergence, if regarded as a branch of the Mammoth, or of intersection, if considered as an independent vein, would be several hundred feet west of the little ravine which divides Bobtail Hill from Gregory Hill, but its exact relations to the Mammoth are not definitely shown by developments thus far made, although claims have been located beyond the assumed point of intersection, and some mining work has been done upon them. It is in the little ravine just referred to that the first discovery of the vein was made.

The most developed portion of the lode begins some 600 or 700 feet northeast of the probable junction with the Mammoth, and continues thence in a northeasterly direction some 1,500 or 2,000 feet, divided among and worked by some half-dozen or more companies. Its general course for this distance is 30° east of magnetic north; or, allowing 15° for variation of the needle, true northeast. Its course in this direction may be traced on the surface down the northern slope of Gregory Hill, across the Gregory Gulch, and over the hill which divides Gregory from Chase Gulch; and along this part of the vein, from the bottom of Gregory Gulch, where is located the mine of the Smith and Parmelee Company, to the top of Gregory Hill, the surface is covered with the shaft-houses, hoisting and pumping works, mills, and waste-dumps of the several companies engaged in mining on the lode. The dip of the vein is nearly vertical, though sometimes inclined either to the northwest or southeast. In the Consolidated Gregory mine the shafts are sunk vertically, and are generally within the walls of the vein; farther to the northeast, on the ground of the Black Hawk and the Briggs mines, the pitch is southeast, though not deviating far from the vertical; the inclination of the pump-rod in the former showing a dip of 83° or 84°; while still farther northeast, in the mine of the Smith and Parmelee, where the vein is divided into two branches, one of which is known as the Gregory and the other as the Briggs, the former dips steeply to the northwest, while the latter dips to the southeast.

The relation of the so-called Briggs vein to the Gregory has been the subject of much discussion and some litigation, some claiming that the two are distinct and independent veins; others, that there is but one vein, which is divided into two parts by an intervening "horse" of ground. The probabilities seem to be in favor of the latter view, though until the developments of each branch are sufficient to determine the limits of the "horse," or show beyond a doubt that the intervening ground between the two branches is actually only an isolated and inclosed fragment, and not a permanent and continuous part of the country rock, there will be some reason for the contrary opinion. The two branches or veins appear at the surface together on the Smith and Parmelee location, and are worked between the same walls for something more than 100 feet. Descending vertically from that point the two diverge, the so-called Gregory dipping about 80° to the northwest, the Briggs at about the same inclination to the southeast, the distance between them, therefore, increasing with the depth, so that at 240 feet below the surface a crosscut shows them to be 72 feet apart.

Horizontally, the two branches diverge in going eastward, the angle of divergence being but a few degrees at first, and farther east, so far as opened, the difference in their courses being about 10°—the Gregory having a course of north 45° east, true, while the Briggs has a course of north 55° east, true. The line of junction, or divergence, of the two branches on the west is not a vertical one, but dips to the westward, so that with increasing depth the division of the vein into two branches is found farther and farther west, occurring near the surface on the western part of the Smith and Parmelee and eastern part of the Briggs location, while on the Black Hawk mine the splitting of the vein into two branches is about 300 feet farther west at a depth of between 200 and 300 feet below the surface.

Eastward, beyond the Smith and Parmelee, the work has not been sufficient, either

on the surface or in depth, to determine the relations of the two branches, and whether they reunite; and if so, where, remains to be seen.

The so-called Briggs lode derives its name from the Briggs Company, which is located on the Gregory vein between the Black Hawk and Smith and Parmelee mines. It is said to have been discovered on this property, and, as an independent lode, is understood to be claimed by that company for a considerable distance beyond the limits of their claim on the Gregory itself. The adjoining companies, however, holding that the so-called lode is but a branch and a part of the Gregory, work it as such within the limits of their claims.

The country-rock of the Gregory lode is generally similar to that of the Bobtail—a granitic gneiss, sometimes poor in mica, at other times abounding in that mineral, and having the appearance of mica-schist. It frequently shows parallel bands or lines of structure, or of varied mineral composition, which usually dip flatly to the eastward.

The walls of the vein are not very regular. Sometimes they are quite smooth and well defined, but usually there is little or no gouge or selvedge, and the removal of the vein-matter near the wall leaves a ragged and uneven surface. Where the walls have been left standing sometimes they frequently scale off and fall in large pieces; sometimes belts of highly micaceous character occur, which soften on exposure to the air, rendering the walls very insecure and requiring substantial support. The width of the vein varies from 2 to 5 feet, sometimes expanding to 12 or 15.

The vein-matter is like that already described in the Bobtail—quartzose generally, sometimes a mixture of quartz and feldspar, much of which has a softened, altered character, carrying a large percentage of finely-divided pyrites. Sometimes masses of pure quartz are also densely impregnated with finely-crystallized iron pyrites. Crystallized quartz occurs sometimes. Free gold is also found, lumps worth $50 being reported.

As in the Bobtail, there is usually a seam of compact ore, consisting of iron and copper gold-bearing pyrites, associated with the wider belt of vein-matter carrying the ore in disseminated form, as just described. The value of this compact ore-seam varies considerably, but is generally less per ton than that of the Bobtail. Some of the richer lots are said to yield from $150 to $200, coin, per ton, but such are uncommon. In fact the value of the lode seems to be less concentrated than in the Bobtail, affording a smaller proportion of smelting ore; but the average width of the Gregory is greater. The yield per ton under the stamps varies according to the proportion of compact and richer pyrites occurring with the poorer vein-matter. The latter yields alone from 5 to 6 ounces per cord, or $10 to $13, in coin, per ton, while the average yield of the Black Hawk rock for six months, crushing everything together, is stated at from $20 to $25, coin, per ton.

The same distinction observed in the Bobtail, that the fine-grained copper pyrites is the richest gold-bearing mineral of the ore, prevails also in this vein. But little galena, and less zincblende, is found associated with the ores of the Gregory.

The distribution of the ore is variable, sometimes occurring in seams 2 or 3 inches wide with intervening bands of poor rock, sometimes expanding to 2 feet or more in width, sometimes pinching out altogether, leaving the vein filled with barren matter, consisting of hard quartz and feldspar. The pay-seam is usually on one wall or the other, but does not seem to follow either uniformly throughout the length of the lode. The prominent working mines on this lode are, beginning about 600 or 700 feet northeast of the junction with the Mammoth lode, as follows:

	Feet.
Narragansett	400
Consolidated Gregory	500
Black Hawk	300
Briggs	250
Smith and Parmelee	300

Southwest of the first named of these are other claims, covering in all more than 1,000 feet, on which some work has been done, while northeast of the last named the lode has been claimed and somewhat developed for another thousand feet, but all of these claims were idle at the time of the writer's visit. So far as I am informed no careful survey has ever been made of any of the mines on the lode, and the existing records concerning the occurrence of ore in the vein are very meager.

The Narragansett Company own 400 feet of the lode, and have opened their mine to the depth of 450 feet. The greater part of this work was done several years ago. Costly hoisting works and crushing machinery were provided at the mine, but operations were suspended in 1866, as the results then obtained were not satisfactory. This condition, it is said, was chiefly due to the want of an efficient method of treating the ores. In 1868 work was resumed by parties who leased the property, and the main shaft was sunk an additional hundred feet. It is said that encouraging results were obtained, but about this time the work on the Bobtail lode was suspended, and such is

the connection between the two veins that the water of one affects the other. As the pump on the Bobtail ceased to drain that lode, the water increased so much in the Narragansett that operations were again suspended.

The Consolidated Gregory Gold Mining Company own 500 feet of this lode, working as one mine what was formerly divided up into several short, independent claims. The mine is opened by three shafts, of which the central one is the chief, having reached the greatest depth and being fitted up in the most substantial manner, provided with pumping and hoisting machinery and other facilities for permanent and extensive operations. This shaft was begun from the surface by the Consolidated Company, and has reached a depth of over 400 feet. The east shaft, sunk by the former owners, was abandoned by the new company as a means of working, and only kept open for ventilation. The west shaft is used for hoisting, the power for that purpose being transmitted from the machinery at the central shaft. The good ground, in the upper portion of the mine, has been pretty much worked out, but, when seen by Professor Hague, [and by myself in 1869,] there were reserves of considerable extent in the lower levels. The vein in the bottom of the mine was looking very well, being from 8 to 12 feet wide in the third level and carrying a strong seam of solid ore, as well as a wide belt of good stamp-rock. This mine usually sends all its ore to the stamping mill without selection of the first-class. According to the statement of the mining captain, about three-fourths of the entire vein-matter is fit for crushing, of which one-tenth part would be suitable for smelting, if desired. The average product of all that is sent to stamps is stated at six ounces of retorted amalgam per cord, equal to $12 or $15, in coin, per ton. The present owners have developed the property with a view to permanent operations and economical management. The central, or main, shaft has been sunk vertically, and timbered in a very substantial manner.

A detailed statement of the costs of sinking and timbering is not accessible, nor is such information readily obtained in Colorado, as but little attention is paid to the classification of accounts or analytical statements of the varied expenses of mining. Labor is generally employed by the day at $3 50, in currency, for miners, and from $4 to $6 per day for mechanics. Drifting, on contract—the miners furnishing their own supplies, except steel—costs from $15 to $20 per foot; sinking, $25 to $55 per foot. The west shaft, being carried down 6 feet by 10 feet, cost $27 50 per foot; the central shaft, 8 by 13 feet, cost at first $45, and later $55 per foot. Square timber and lumber cost $35 per 1,000 feet, board measure. The owners of this mine built a large mill containing 50 stamps, which commenced operations late in 1868.

The claim adjoining the Consolidated Gregory on the east is 300 feet in length, and is owned and worked by the Black Hawk Gold Mining Company. The same company own other claims on the same lode, one of them 200 feet in length, about 1,200 feet farther west, between the Narragansett mine and the Mammoth lode; the other 250 feet in length, about 1,000 feet farther east, on the eastern extension. They also own, as already stated, 76 feet on the Bobtail, besides some less developed property in the region.

There are three shafts, one central and one near each end of the mine. Of the two latter the westernmost has been abandoned, so that operations are carried on only through the other two, which, in August, 1869, had reached a depth of 576 and 531 feet. In the northeastern part of the mine the vein, at a depth of about 300 feet below the surface, is divided into two branches, which are generally considered, although the connection had not been actually traced, as the same branches that in the claims farther east are distinguished as the Gregory crevice, on the northwest side, and the Briggs crevice on the southeast side. The line of junction of these branches appears to be between the eastern and the central shafts, occurring, as has already been said in the foregoing, farther and farther west as the depth increases. Thus all the ground in the upper portion of the mine and for the whole depth west of the central shaft has been worked as one vein, while below a depth of 250 or 300 feet, in the eastern portion, the two branches have been recognized. It should be observed that in the eastern, lower portion of the mine, where the Briggs has been chiefly worked, the Gregory is small, poor, and so far not worked.

The general course of the Gregory or main crevice on this property is north 45° to 47° east, true, while that of the Briggs, near its point of divergence from the Gregory, is north 50° to 52° east. The dip of both branches is southeasterly, though not deviating far from the vertical. The average width is 3 or 4 feet, though in the western part of the mine, where appearing as one crevice only, it expands in places to 12 or 15 feet. The pay-ground, as already shown, consists usually of a solid seam of pyrites, with a course of vein-matter impregnated with the same. The compact seam is frequently 2 or 3 feet wide. The whole of the vein-matter is usually taken out and crushed together in the stamping-mill, yielding, it is said, from $20 to $25 per ton, in coin. The bottom of the mine, where accessible, was showing an excellent seam of ore. The mine has been worked almost altogether by underhand stoping, and nearly all the ground known to be productive has been taken out, as fast as it became accessible.

There are two stamp-mills belonging to the company, one containing twenty stamps

set up at the mouth of the eastern shaft, and run by the same engine that does the pumping and hoisting; and one containing sixty stamps located in the town of Black Hawk, near the mouth of Chase Gulch.

During 1867 the product of the mine was 12,193¾ ounces of crude bullion, yielding in currency $279,647 76, or $22 81 per ounce. The number of cords or tons from which this product was obtained is not stated, but the yield of the rock at that time is said to have been 10 ounces of bullion to the cord. Assuming this to be correct, the quantity worked would have been 1,220 cords, which, at a trifle more than eight tons to the cord, would be equal to 10,000 tons. On this basis the yield of the rock would have been $27 96 per ton, in currency, or $20 11, in coin, allowing the average value of the ounce of amalgam to be $16 50. The yield of 10 ounces of bullion to the cord is much higher than that now obtained, and is perhaps overstated. Another method of arriving at the quantity is by considering the average amount treated weekly, which is stated at about 32 cords. This in fifty weeks would amount to 1,600 cords; and allowing seven and a half tons to the cord, which is, perhaps, more nearly correct than eight tons we have a total of 12,000 tons of ore, of which the yield per ton would be $23 30, in currency.

During this period the costs were as follows:

Mining expense	$137,214 65
Milling expense	39,998 02
Teaming expense	17,212 96
	194,425 63

If the quantity of ore produced was 12,000 tons, the cost of mining was $11 43; of milling, $3 33; of teaming, $1 44; and of all the foregoing together, $16 20 per ton, in currency.

The total product being	$279,647 76
And the above-named costs	194,425 63
The excess of yield over cost was	85,222 13

During the latter half of 1868, when operations were resumed, there were produced 3,942$\frac{33}{100}$ ounces of amalgam, worth $88,379 82 in currency. If the quantity of ore be assumed in about the same proportion to the product as in the former case—that is, say, one ounce of amalgam per ton—we have 3,942 tons, producing $22 42 per ton, in currency.

The costs during the same period were, for mining expense, $45,206 86, and for teaming expense, $6,441 42; which, assuming the quantity to be as above, are equal to $11 52 per ton of ore for mining, and $1 63 per ton for hauling. Milling expenses during that year were a little more than counterbalanced by the profits derived from working custom-ores; the actual costs, however, were not less than $20 per cord, or $2 66 per ton, making a total of $15 81 per ton, exclusive of office expense and interest. Judging from the data given below concerning the operations of 1869, the number of tons above given is too small. By increasing this number, the yield per ton and the cost of working per ton will be correspondingly decreased.

During the first half of 1869 there were produced 3,177 ounces of retorted amalgam, worth $65,755 94, in currency. The quantity of ore is stated at 622¾ cords, equal to 4,670 tons. The average yield per cord is 5$\frac{1}{10}$ ounces of retorted amalgam. During this period the mining expense was $37,833 80, and the teaming expense $2,899 70. Accepting 4,670 as the number of tons worked, we have a mining expense of $8 10; of teaming, 62 cents; and estimating milling, as before, at $2 66, we have a total cost for the above items of $11 38, and a yield per ton of $14 08 in currency.

The Briggs Gold Mining Company's property adjoins the Black Hawk on the east. The mine is 250 feet in length and opened by two shafts, one of them 71 feet from the east line, the other 51 feet further west. Both are sunk on what is considered the Gregory crevice, but the southeastern branch of the vein, the Briggs, has been worked to a greater depth and yielded a larger amount of ore than the Gregory. On the eastern end of this property the two branches are near together at the surface, diverging, however, slightly in depth. Horizontally, the branches are found to diverge between the two shafts, the line of junction dipping westward, so that, as has been already shown, at a depth of 300 feet the division of the vein into two parts occurs on the Black Hawk property.

The course of the Gregory crevice is about north 45° east; that of the Briggs north 55° east, true. Both branches dip slightly to the southeast. Near the surface the two branches are said to have been worked as one vein, but being now entirely filled with old stulls and waste-rock, no opportunity is afforded for studying their relations to each other. At the depth of 100 feet or thereabout they are worked separately from the point where they diverge, leaving the tongue or wedge of barren country-rock standing between them.

The Gregory crevice is worked to a depth of 130 feet for the whole length of the property, and below that has been found rather unpromising, while the Briggs, on the eastern part of the ground, has been worked to the depth of more than 400 feet and found very productive.

The Briggs Company have a large mill, containing fifty stamps, located on the mine between their two shafts, so that the ore is delivered for treatment with the least possible expense for handling. The power for driving the mill is also applied to the hoisting and the other necessary work of the mine, and is furnished by a steam-engine of 22½ inches diameter of cylinder. Steam is supplied by two tubular boilers. The hoisting power is communicated by belting to the winding apparatus, which is, in most respects, similar to that already described.

This mine is said to have been one of the most productive and profitable of any in Colorado. It has, however, suffered some embarrassments, and in the summer of 1868 had, after a period of idleness, resumed operations under different owners. The production had therefore been suspended, the mill being worked on custom-ore. Since that time it is reported as having been worked very successfully.

The average value of the first-class ore produced by this mine appears from 136 tons sold, during the first half of 1869, at the Smelting Works, containing 5¼ ounces of fine gold and 10¼ ounces fine silver to the ton. During seven months of 1869 the product of the milling rock of this mine was about $55,000. The total product, including smelting ore, was $70,000, currency, or about $10,000 per month. The mine is reported to be steadily improving in productiveness and profitable operation.

The Smith and Parmelee Gold Mining Company own and work the next adjoining mine on the east, claiming 300 feet on the so-called Gregory crevice and 800 feet on the Briggs. Both veins, or branches of the same vein, are worked by this company for the distance of about 250 feet, measured from the Briggs claim, beyond which neither has, so far, been found very productive. The Gregory branch has been worked to the depth of about 150 feet, below which it has not been much developed, the work having been chiefly confined in depth to the Briggs branch. This latter has been worked to a depth of more than 550 feet, and has furnished by far the greater portion of the whole product of the mine. It is on this property that the divergence of the two branches is so far found to be the greatest, but little being known of their relations to each other further east. In the crosscut, at a depth of 240 feet, they are 72 feet apart. The two branches maintain on this property the courses observed further west with considerable regularity, that of the Gregory being generally north 45° east, and that of the Briggs north 55° east, true; but so far as observed—that is, to a depth of 150 or 160 feet—they have a more divergent dip, that of the Gregory being about 80° to the northwest, while that of the Briggs is generally about 80° to the southeast.

The Briggs has received the most development. Its average width is 3 or 4 feet. Its walls are not always well defined. The filling of the vein is generally similar to that already described. Seams of solid iron and copper pyrites, chiefly the former, occur with belts of quartzose and feldspathic material, carrying ore more widely distributed through the mass. In the bottom of the mine, where, by reason of the underhand stoping and lack of reserve ground, the only opportunity is afforded of seeing the ore-vein in place, there was a strong seam of iron and copper pyrites visible at the time of the writer's visit. The mine for some time past has been producing at the rate of 600 or 800 tons of ore per month for stamping, besides a small proportion of first-class, of about the same quality as the first-class ore of the Briggs Company. The milling ore is said to produce six ounces of crude bullion to the cord, worth $100 in coin, or $13 to $14, coin, per ton. The costs of mining and milling are stated at about $12, in currency, per ton.

The mine is provided with a twenty-five-stamp mill, conveniently placed at the mouth of the shaft. It was rebuilt in 1869, and has great advantages for economical work. The engine in the mill furnishes power for hoisting and pumping from the mine.

Beyond the Smith and Parmelee is the claim of the New York Gold Mining Company, on which a shaft has been sunk between 200 and 300 feet in depth. The claim, however, is disputed by the Smith and Parmelee. Nothing has been done on it for some time. Still further east are other claims, covering several hundred or a thousand feet, but not yet much developed.

The Bates lode is several hundred feet northwest of the Gregory, and nearly parallel to that vein, or rather to the so-called Briggs, having, so far as observed, a nearly identical course with the last named, north 55° east, true. It is traced on the surface down the northern slope of Gregory Hill, across Gregory Gulch, and over the hill dividing the last named from Chase Gulch. It has been opened and worked to a considerable depth for about a thousand feet in length, and claims are located on it for a still greater distance. On the lower part of Gregory Hill, where it is commonly known as the Bates-Hunter lode, there are several short claims that have been worked by private parties; one of these claims, 160 feet in length, belonging to Borem, Mellor & Company, has been worked by them to a depth of 100 or 200 feet, producing excellent milling ore at a handsome profit to the men engaged in it.

Farther to the northeast, the Rocky Mountain Gold Mining Company have a claim of 250 feet, located just in the bed of the Gregory Gulch, on which they have sunk three shafts to the depth of 200 or 300 feet, having on the surface a liberal provision of hoisting and pumping machinery, comprising an excellent engine of 40 or 50 horse-power, with boilers and winding apparatus.

Adjoining their claim on the east is the Union Mine, 300 feet in length, and worked to a depth of 350 or 400 feet. The vein is 5 or 6 feet wide, on an average, but expanding sometimes to 15 or 20 feet, and pinching up in places to a few inches. In general, however, it appears in the Union Mine to be one of the strongest and most uniform lodes in the Territory. The mine has been opened by two shafts, of which the western is the deeper and the main shaft; the other is not in good working condition, and is only useful as a ladder-way and air-passage. The company have a twenty-stamp mill in Chase Gulch, about a half mile from the mine, in which the lower-grade rock, or that of second quality, is crushed and subjected to the common process, while the higher grade, or first-class ore, is selected for treatment by other methods. This is said to contain about 5 or 6 ounces of fine gold and 20 ounces of silver to the ton, worth from $120 to $140, in coin. Concerning the yield of the rock, or detailed costs of operations, but little definite information was found available. The low-grade ore is said to yield, in the ordinary stamping process, from 4 to 12, averaging probably 5 or 6, ounces per cord, or $12, coin, per ton. Concerning costs of production, it was said by the president of the company that the whole expense of operation is more than paid by the product of this low-grade rock, leaving value of the first-class ore as a surplus of profit to the company.

The Bobtail, Gregory, and Bates lodes have been described as having convergent courses, which, if continuous, would lead them all to a union with Mammoth lode. This vein extends in an east and west direction, from near the western terminus, so to speak, of the Bobtail lode. It has been traced thence for a distance of 2,000 or 3,000 feet, and is covered by mining claims, on which work has been done, with some success, near the surface, but not generally below a depth of 200 feet. The deepest of the several mines on the lode is that managed by Judge Morse, of Central City, which is located near the assumed point of the junction of the Gregory with the Mammoth. Several shafts have been sunk on this vein, one of them over 300 feet, finding a large vein, but filled with iron pyrites that is almost entirely wanting in the precious metals so commonly associated with this mineral in Colorado. Not much drifting has been done in depth, so that but little is known of the lode except as revealed by the sinking of the shaft. Extending the line of this lode in a westerly direction, but a little distance beyond the point to which it has been traced, and crossing Spring Gulch, we come to Quartz Hill, which has been, and still is, the scene of active mining enterprise. This hill has a general east and west trend, forming the divide between Nevada Gulch, on the north, and the Illinois and Leavenworth Gulches, feeders of Russell Gulch, on the south. On the east it is drained by Spring Gulch, which, uniting with Nevada Gulch, just above Central City, becomes thus a feeder of Gregory Gulch, about a mile above its junction with North Clear Creek. The hill, in that part most occupied by mining operations, rises to an altitude of 600 or 700 feet above the level of the streams at its base. These several gulches were the sources of large quantities of gold in the early days of placer mining in these regions, and some of them continue to yield liberally, under the simple operations of sluice mining. The rich character of the washings of the surface naturally led to the prospecting of the hill for the deeper sources of the metal, and many lodes have been discovered, some of which have been developed to a greater depth than any others in the Territory. The lodes inclosed in this hill have generally a nearly east and west course, with a nearly vertical dip, but inclined slightly toward the south, closely resembling the Bobtail lode in these respects. The country-rock of the hill is essentially the same as that already described farther east. It generally has the features of gneiss, though often quite granitic in character. The veins average perhaps somewhat less in width than those that have been already described, but they are regular, well-defined, and equally promising as to permanence. The ores have the same general character, with some differences that will be noticed below. Among the many lodes that have been opened and partially developed the best known are the Burroughs, Kansas, Gardiner, and Illinois, on that part of the hill that has been longest known and worked to the greatest depth, while farther west are the Flack, American Flack, California, and others, which are of increasing importance. The ores of these latter are distinguished by the large proportion of argentiferous galena, zincblende, and silver sulphurets that are associated with the iron and copper pyrites, giving them sometimes a high value in silver, but rendering difficult or practically impossible the extraction of the gold by any simple process yet available. Some of the more prominent lodes of Quartz Hill will be described, selecting for purposes of illustration one or more of the leading or characteristic mines that are located on them.

The Illinois lode is traced along the north side of the hill, not far from its crest. The principal developments on it have been made in the North Star mine, owned by a

company in Chicago, and managed by Mr. George Mitchell. This mine was worked by the company referred to until 1869, when it became involved in financial difficulties, and operations were embarrassed, if not suspended. The mine was opened by two shafts, one of which was sunk to a depth of 234 feet, and at 160 feet below the surface a level was driven over 700 feet in length. From these developments the vein appears to have a course of north 60° east, true, though its average course for a longer distance than that observed is said to be more to the eastward, and thus more nearly parallel with the other neighboring lodes farther south, that trend north 85° east. Its dip is to the south 84°, and so far as sunk upon is very regular. The average width is about 2 feet, frequently expanding or contracting to greater or less dimensions. Its walls are generally smooth and well-defined, sometimes polished, grooved, or striated, showing indications of movement. Usually there is a soft "gouge," or seam of clay, between the walls and the filling of the vein. The latter is chiefly quartz; sometimes white, hard, and amorphous, carrying little or no valuable mineral; sometimes showing a sparse distribution of crystallized iron pyrites throughout its mass; but most commonly the vein-matter is a mixture of siliceous and feldspathic material, in which occur small seams or scattered particles of pyrites, making a very fair quality of stamp-rock, and, as in the other veins already described, associated usually with a narrower but solid seam of compact pyritous ore. The latter is from 2 or 3 to 10 or 12 inches thick, and furnishes a small proportion of smelting ore. This proportion appears, from all available data, to be between one-twentieth and one-tenth of the whole number of tons produced. The valuable mineral in the vein consists chiefly of iron pyrites, with a lesser proportion of copper pyrites and, as a characteristic feature, some arsenical pyrites; with these are associated some zincblende and galena. The yield of this ore in silver is shown by the assays of Professor Hill to be larger than is usual in the pyritous ore veins of the district, the average of 42 tons sold by the mine at the smelting works, during the summer of 1868, being about four ounces of fine gold and twenty ounces of fine silver to the ton. The yield of stamp-rock during a run of thirty-four weeks in the summer of 1868, when 200 cords, or 1,500 tons, were supposed to have been treated, was 1,538 ounces of crude bullion, or about one ounce per ton. The average value of the ounce of this bullion is stated at $15 50, coin.

The filling of the vein is generally soft, so that much of it may be removed with a pick, requiring comparatively little blasting. This facilitates considerably the working of the ground, both drifting and stoping being done for somewhat lower prices than in the majority of the veins in the district.

The mill in the building adjoining the west shaft-house contains twenty-two stamps, weighing 550 pounds each, and has a crushing capacity of about 20 tons per day. The average yield of the stamp-rock has been already shown to be about $15 50, coin, per ton. The mine was producing regularly in 1868, but all its yield and more has been absorbed in the costs of the work already described, which is said to have involved the expenditure of more than $100,000. In 1869 the company became much embarrassed financially, and its regular operations were interfered with, although some work was still in progress.

The Gardner lode is nearly parallel to the Illinois, and between 300 and 400 feet further north, its outcrop being farther down the slope of Quartz Hill, toward Nevada Gulch. Its course is north 85° east, true. Its dip is 75° to the south, and both course and dip, so far as observed by the writer, are very regular. The lode was discovered and partly opened as early as 1860, and has been worked, with some intervals of interruption, from that time to the present. It has been claimed and somewhat developed for a length of over 800 feet, but the most important operations on the vein are in the Clark-Gardner mine, a claim of 200 feet in length. The adjoining claims, both east and west, have been worked to varying depths, not exceeding 200 feet, and have yielded some handsome returns, and as they are partly owned and controlled by the same people who own the Clark-Gardner, there is hope of a consolidation of interest that will bring at least 800 feet under one management. This is much to be desired for the interest of all owners, as under the present conditions the costs of equipment, opening of ground, and administration of such short claims are so great as to absorb a large share of the proceeds.

The lode, as shown in the Clark-Gardner mine, is a large and regular vein. Its width is seldom less than 3 feet and often 10 or 12. Its walls are smooth and well defined, standing firmly, and involving but comparatively little expense in timbering.

The ore, as in the veins already described, is a mixture of iron and copper pyrites, carrying, however, a considerable proportion of galena and zincblende. The valuable mineral appears to be more widely diffused throughout the general filling of the vein than generally observed elsewhere, for while there is usually a compact seam of pyritous ore, it is almost always narrow, and the proportion of high-grade ore, worthy of selection for smelting, is very small. During several months of 1868 not more than 20 tons of first-class ore had been selected from 1,500 or 1,600 tons of ore produced, equal to one in about 80. To compensate for this there is a good degree of uniformity existing in the quality of the milling ore, and occurring, as it does, in a comparatively wide vein,

it can be extracted cheaply. The main filling of the vein is a siliceous and feldspathic mixture, but where the vein is wide there is frequently what appears to be an inclosed mass or "horse" of country-rock, granitic in character, though carrying an impregnation of pyrites through it. In the Clark-Gardner mine one-half or two-thirds of all the vein-matter broken is sent to the stamping mill, and yields, on an average, about 6 ounces of crude bullion, or $100 coin per cord, equal to $12 or $14, coin, per ton.

The proportion of first-class ore of the Clark-Gardner mine has already been shown to be small. The sale of this quality to the Smelting Works amounted, in eight months of 1868, to 38 tons, averaging 3¼ ounces of fine gold and 11¼ ounces of fine silver to the ton.

The Clark-Gardner mine, 200 feet in length, is opened by two shafts, the westernmost having reached a depth of about 360 feet. The ground near the surface was generally unproductive, but at the depth of 80 or 100 feet a good body of pay-ore was encountered, and the mine below that, excepting some poor spots, has been mostly worked out to a depth of 300 feet. The costs of working the ground are comparatively light. Drifting costs from $5 to $10 per foot; sinking, 8 feet by 5, costs $20 per foot; stoping, from $12 to $22 per running fathom. Much of the ground in the lode can be picked down, and comparatively little powder is required. Two men have broken a fathom of ground in one day. Eight men have supplied the stamping mill with not less than 20 tons of ore per day for two months. The ground is comparatively dry and the costs of timbering are light. The mine is provided with hoisting machinery consisting of a small portable engine that drives a simple winding apparatus by belting, in the common way. The shaft-house is a large stone building, originally designed to contain a stamping mill that is not yet set up. The power provided is sufficient for both hoisting and stamping on a small basis of operations.

The Burroughs lode is about 400 feet north of the Gardner. Its outcrop is farther down the slope of the hill, and about 100 to 150 feet above the bed of the Nevada Gulch. Its course is almost exactly parallel to that of the Gardner, being, where observed by the writer, north 85° east, true. Its dip is nearly vertical, or slightly to the south, its average inclination in the Ophir mine being 85°. It is one of the earliest discovered and most developed lodes in the Territory, the main shaft of the Ophir mine having reached, in the summer of 1869, a depth of 630 feet. It is opened for a continuous length of more than 2,000 feet, and worked along that distance to depths varying from 200 to 500 or 600 feet. Unfortunately, it has the practical disadvantage, in common with many other valuable lodes of Colorado, of being subdivided into many different claims, the greater number of which are too short to make independent mines, and only serve as obstacles to a consolidated and comprehensive management. One company, the First National, although owning more than 600 feet of the lode, hold it in three or four disconnected portions, between which several other claims intervene, a condition that must greatly increase the cost of operations, if not presenting an effectual barrier to systematic development.

The following list shows the claims on that part of the lode that is distinctly traced and opened by mining work, beginning on the east and proceeding toward the west end. The length of each claim is given, and the depth attained by their work at the time when the accompanying section was prepared in 1868, since which little or no important change has been made:

Name of claim.	Length.	Depth reached.
W. H. Cushman	267	300
Burroughs Gold Mining Company	155	220
Lacrosse	50	*a* 178
Burroughs	100	60
Colorado	200	305
Conlee	20	30
Ophir	462	560
First National	183	265
Gold Hill	70	128
Baltimore and Colorado	40	200
Quartz Hill	90	240
Gold Hill	20	....
First National	233¼	230
McCabe	66¾	30
Andrew	90	93
First National	100	60
First National, (one-half interest)	200	....

a Cut by tunnel.

The Ophir is the deepest and most extensively worked of all the mines on the lode. It is situated centrally, as regards the developed portions of the vein, and may properly serve to illustrate the general features of the latter. The Burroughs vein, as shown in the Ophir, resembles in most respects the lodes that have already been described. The country-rock is the same half-gneissic, half-granitic rock already observed. The walls are usually well defined, smooth, and regular, sometimes carrying a thin gouge of clay, sometimes having the seam of ore resting directly upon it without anything intervening. The vein, however, is not wide as compared with other leading veins, varying from 8 to 10 inches to 3 or 4 feet, seldom exceeding the latter.

The vein-matter and the ore, consisting usually of a solid seam of the latter from a few inches to more than a foot in thickness, and associated with a belt of siliceous and feldspathic material highly charged with pyrites, present the same general features in mode of occurrence and distribution that have been already noted in connection with the other lodes, but the pyritous ore is more exclusively iron rather than copper pyrites: in fact, the small proportion of the latter, at least in the Ophir, is very marked, and the iron pyrites is not only gold-bearing but the Ophir ore carries more silver than is generally associated with the ores of the district similar to these in other respects, the average assay of the first-class ores sold at the smelting works showing about 6 ounces of fine gold and 12 ounces of fine silver to the ton. The ground is generally hard, requiring the aid of powder for its removal. Very little of it can be picked down. The mine is opened by means of two shafts, one at 125 feet from the eastern boundary of the property, the other about 60 feet farther west. Both of these shafts have reached a depth of about 600 feet. The upper part of the mine was not worked by the present owners and little or nothing is known now of the distribution of ore in the ground taken out; a considerable portion of the mine was poor and is left standing, but nearly all above the 467-foot level is regarded as exhausted of its valuable contents. The earlier owners worked out what they found without much attempt at regular methods, and the first level driven as a preparation for back-stoping was carried forward by the present management at a depth of 467 feet. Sixty feet below that another level was driven nearly the entire length of the property and stoping carried on above it, while the east shaft was sunk with the view of opening another level below in advance of the needs of the mill.

The rock, when brought from the mine to the surface, is first assorted, selecting the first-class ore for smelting, and separating the waste-rock, that is thrown away, from the low-grade ore, that is sent to the stamps.

The company have a twenty-four-stamp mill, which is situated in the valley directly below the shaft-house, so that a gravity tram-road, a few hundred feet in length, is laid on the hill-side, by which means the ore is conducted in cars from the shaft-house to the mill, the descending loaded car bringing the light one up by its greater weight. The twenty-four-stamps, weighing about 500 pounds each, have an average capacity of 16 to 18 tons per day. The yield of the rock is about six ounces of crude bullion to the cord, equal to $13 or $14, in coin, per ton. In addition to this is the product derived from the tailings, which is considerable.

The following statements, furnished by the superintendent, Colonel Randolph, refer to 1868. They are permanently interesting, however; and such well-arranged information is rare in Colorado.

Month.	Fathoms stoped.	Tons of ore mined.		Tons crushed in own mill.	Cost of mining.	Cost of milling.	Total cost per ton.
		1st class.	2d class.				
April	$46\frac{1}{2}$	8	366	....	$12 06	....	....
May	61	15	430	180	16 80	$4 62	$21 42
June	$71\frac{3}{8}$	6	586	296	12 10	4 26	16 36
July	$82\frac{8}{10}$	$4\frac{1}{2}$	594	379	11 42	2 85	14 27
August	53	12	416	455	13 79	3 65	17 44

The fluctuation in the cost of both mining and milling is due to a variety of circumstances, such as the variable amount expended on ordinary repairs in any given month, and the quantity of rock produced or milled during that month.

Thus, in the months of July and August, the costs of milling were less than in the foregoing, because the expenditures for repairs were not so great during those months while the capacity was enlarged by increasing the speed of the stamps and the number of days of running, thus diminishing somewhat the costs per ton.

The first-class ore, sold at the smelting works, netted the mine, in the month of May, \$93; in July, \$98; and in August, \$104 per ton, in currency. The yield of the stamp-rock, including that treated in the company's mill and in custom mills, was, in May, \$24 50; in June, \$15; in July, \$12; and in August, \$19 per ton, in currency. The total receipts from ores and sale of tailings, and expenditures of all sorts, during the four months referred to, were as follows:

Month.	Receipts.	Expenditures.
May	\$16,491	\$11,731 12
June	8,766	10,306 48
July	8,310	9,683 36
August	12,000	8,798 62
Total	45,567	40,719 58

The proportion of first-class or smelting ore to the second-class, or stamp-rock, appears from the accounts to be about one in fifty.

Thus we have in—

April	8	in 374	or 1 in	46
May	15	in 445	or 1 in	30
June	6	in 592	or 1 in	97
July	4.5	in 598.5	or 1 in	133
August	12	in 428	or 1 in	35½
Or, for the five months	45.5	in 2,437.5	or 1 in	53.6

This statement shows that the great bulk of the ore produced by the class of veins represented by the Burroughs is of the low-grade, or stamping rock. The proportion of the two classes above given differs considerably from the general estimate of those who do not keep careful accounts, but, so far as the data furnished by this mine and others, where the relative quantities of the two classes of ore are accurately noted, afford any basis for judgment, the proportion of first-class to second-class ore is very small.

The relation existing between the amount of ground mined and the quantity of stamp-rock produced is indicated by the following figures:

Month.	Fathoms of ground stoped.	Tons of stamp-rock produced.	Tons per fathom.
April	46.5	366	7.87
May	61.	430	8.15
June	71.66	586	8.17
July	82.8	594	7.17
August	53.	416	7.83
Or an average of	....	....	7.60

The fathom paid for in stoping is the running or superficial fathom; that is, six feet measured on the length and the dip of the vein, but varying in width according to the thickness of the vein. Estimating the average width of the stope at a little more than three feet, the weight of the solid fathom would be ten tons, from which, as we have just seen, seven and six-tenths tons of stamp-rock are obtained, or about three-fourths of the ground broken. According to this, a fathom of stoping ground produces a cord of stamp-rock, which yields, on an average, six ounces of crude bullion, worth about \$100 in coin. The price paid for stoping varies very much, according to the character of the ground. It is sometimes as low as \$25, and sometimes more than \$50 per fathom. Drifting costs from \$12 to \$20 per foot. Sinking the shaft, 7 feet wide by 14 feet long, at the date of the writer's visit in 1868, cost \$52 50 per foot, the miners furnishing their own supplies.

The foregoing notes concerning the operations of this mine were obtained in the

latter part of 1868. Shortly thereafter the company became embarrassed, financially, and, when visited in 1869 but little work was in progress. A few miners were at work on their own account.

There are several claims on the Burroughs that have been worked to considerable depths, but, during the past year or two their development has not been very vigorously prosecuted. The Gilpin was steadily worked for a long time, but, in the summer of 1869 little or nothing was in progress on that claim. The First National Company, owning several disconnected claims on the lode, resumed active operations, in 1869, on that which adjoins the Ophir on the west, and have since been steadily engaged in its development. Their shaft, on this claim, has reached a depth of nearly 500 feet. Stoping has been in progress, during the past winter, between the 400-foot and 470-foot levels, furnishing ores that yield an average of $10 50, coin, per ton. A careful system of account-keeping has been inaugurated in this mine, and the following statements, setting forth some of the results of their operations, will be found interesting as throwing light on the relations existing between cost of production and yield of the ore. It will be seen that the former exceeds the latter, and the experience of this mine is one illustration of the disadvantage under which a short claim is worked on a vein like the Burroughs, a fair representative of the Colorado gold-bearing lodes. The vein is narrow, the average value of the ore is low, and the pay is not uniformly distributed. A vein of this character needs all the advantages that may be derived from economical and systematic methods of work. Here, however, is a claim, 183 feet in length, working through a shaft nearly 500 feet deep, the cost of sinking which is 10 per cent. of all the expenses of the company. As the mine has no connection with its neighbors the shaft can only aid in the development of a small part of the ground for which it would be sufficient if the claim were longer. The cost of hoisting works, the consumption of fuel, labor of the engineers and some other men, the cost of superintendence and other management of the company's affairs, are nearly or quite as much as they would be if the production of the mine were ten-fold greater. Thus, the costs per ton are much increased, and ore, rich enough to afford a profit under favorable circumstances, is produced at a loss under existing conditions.

This is true of many of the mines in Colorado. Some of the best lodes, apparently possessing all the necessary qualities for profitable working, under one comprehensive and economical management, are divided into a multitude of short claims, worked independently of each other, at great expense, and losing their possible profits for the lack of consolidation.

The following statement shows the operations of the mine, in detail, for five weeks, from October 9 to November 13, 1869:

Week ending—	Tons mined.	Ordinary expenses per ton.	Special expenses per ton.	Total mining expenses per ton.	Tons crushed.	Cost of crushing and hauling. (Custom mill.)	Total cost per ton.	Yield per ton.
October 16	87	$6 96	$1 71	$8 68	56	$5 38	$14 06	$16 43
October 23	60½	10 17	1 80	11 97	72	5 38	17 35	10 29
October 30	77	7 76	1 82	9 59	74	5 38	14 97	12 01
November 6	67	8 68	0 35	9 03	76	5 38	14 41	11 79
November 13	117½	4 97	1 93	6 90	....	4 45	11 35	....

All expenses are included in the foregoing; among special costs is included the sinking of the shaft.

The following is a summary of operations from October 9, 1869, to January 1, 1870, including the foregoing:

Number of tons of stamp-rock raised and milled	850
Average assay value in coin—gold, $25 13; silver, $1 94—total	$27 07
Number tons smelters' ore raised and sold, (1 in 65)	13.27
Average assay value in coin—gold, $131 21; silver, $16 22—total	$147 43
Total tons raised	863.27
Average assay value, coin	$28 92
Average yield, per ton, of milling ore, in currency	12 68
Average yield, per ton, of smelting ore, in currency	110 07
Average yield, per ton, of all ore, in currency	14 17

Average cost, per ton, for ordinary expenses of mining and milling	$13 59
Average cost, per ton, for special expenses	2 08
Total average cost, per ton, in currency	15 67

Counting gold at 20 per cent. premium, the average percentage obtained of the value of the low-grade ore was 39 per cent. by milling, and 62 per cent. of the value of first-class ore, obtained by sale to the smelters.

On the same slope of Quartz Hill with the Burroughs, but from half a mile to a mile farther west of the principal developments on that lode, and higher up the valley, is another group of mines opened upon ledges that from their course, dip, and relative position seem to belong to the same class as the Burroughs, Gardner, Illinois, and their associated veins, but which present a marked difference in the character of their ores, carrying a much larger proportion of argentiferous galena, zincblende, and sulphurets of silver. Assays of the ore frequently show a very high value in the last-named metal. Prominent among these are the California, Indiana or Hidden Treasure, Flack, Mercer County, Forks, American Flag, and others. The Mercer County lies east of and in line with the Flack, on what is understood to be the same vein, but the mines are separated by a dry, shallow ravine, which crosses their course. The California and the Indiana bear a similar relation to each other, the two names applying to different parts of one vein, the last named lying west of the ravine, just referred to, and the California lying east of it. The course of the California, continued still farther east, shows it to be very nearly in line and probably identical with the Gardner lode, already described. Forks is between the Flack and the California, having, apparently, a course considerably north of east, and consequently intersecting both, if all three are continuous and regular. It is worked actively to a depth of over 300 feet, and yields very good ore. The American Flag, still farther north, not far above the bed of the stream, has also been worked to a depth of several hundred feet and gives indications of much value.

A more minute description of the Flack Mine, on the Flack lode, and of the claim until lately known as the Stalker and Stanley, on the California lode, will suffice to represent the general character of this group of veins. The Flack was one of the early discoveries of the district and was worked in 1862. The top quartz is said to have yielded a good deal of money. At a depth of 60 feet the crevice was small and poor and continued so for 100 or 125 feet farther, when a good pay-seam was found. Difficulties among the owners led to a subsequent suspension of work, which was only resumed again in June of 1868. Two shafts are being carried down for permanent work, with the intention of opening ground by successive levels and stoping overhand. One of these had reached a depth of 400 feet in 1869. Drifting and stoping were in progress in the neighborhood of both shafts. The vein is shown by these developments to be narrow, varying from three or four inches to two feet. The walls are of gneiss, sometimes passing into granite, and, where broken, frequently show lines of bedding or structure dipping eastward. The walls are generally very well defined and smooth and show evidences of movement in the beautifully-polished and striated surfaces that are formed on the ore seam where in contact with one or the other wall. Sometimes there is a distinctly-marked selvage of clay between the wall and the harder filling of the vein. The vein-matter is chiefly quartz; where associated with pay it is of a softened or sometimes friable character, mixed with some feldspar; where poor, it is harder, sometimes forming a granulitic mixture of quartz and feldspar. This is generally, not only in this but in other veins of the district, the character of the "cap" or barren ground of the lode. The "cap," a term usually employed to express the impoverished condition of the vein, may be due either to the pinching together of the walls of the fissure, or, where the latter maintain their regular distance apart from each other, to the filling of the vein with barren rock, usually resembling granulite or the granite of the country. Thus in the east shaft of the Flack, which passes through a hundred feet or more of "cap," the walls were observed to be two feet or more apart: on the south wall there seemed to be a fissure by itself, only an inch or two wide, and filled with a soft clayey and siliceous material, next to which was a belt of barren rock that might be described as a granulite, or a granite poor in mica; and north of that, next the north wall of the vein, another and wider belt of true vein-matter. Bunches of the latter may be found in places scattered through the "cap." This condition of things may suggest the idea that these veins were originally formed or filled by dikes of granite or granulite, and that by a subsequent enlargement or widening of the fissure the siliceous and metal-bearing vein-matter was introduced by other processes of infiltration or segregation by which it is generally believed that fissure veins have been filled. The ore-seams and their gangue are frequently, indeed generally, arranged in layer or banded form, with a considerable degree of parallelism and with the drusy character of true vein filling. Movement in the walls would naturally occasion the irregularity in the width of the crevice and the shattering or fracturing of the original dike material would afford opportunity for the intermixture of the newer vein-matter with the old. Movement in the case of the vein now under consideration is clearly evidenced by the "slickensides," or polished surfaces, already referred to.

It has already been stated that, where ore-bearing, this vein carries a considerable

proportion of zincblende and galena. These occur sometimes intimately mixed with the iron and copper pyrites, while in some places they are arranged in distinctly separated seams. In the stope east of the east shaft the vein was 12 or 15 inches wide; on the north wall was a very thin selvage of soft, clayey material, followed by a seam of dark-colored blende and galena, two or three inches wide, somewhat mixed with and succeeded by a seam of greenish, siliceous, and perhaps talcose vein-matter, carrying finely-divided iron pyrites; then a seam of solid iron pyrites, two or three inches thick; the remainder of the vein was a quartzose material carrying finely-distributed pyrites suitable for crushing in the stamp mills. In this place there was but little copper present, though elsewhere copper pyrites is sometimes largely represented, and argentiferous gray copper occurs sometimes with the galena and the zincblende.

Concerning the yield of the rock, on a large working scale, but little positive information was available. The stamp-rock, it is said, yields about one ounce of retorted amalgam per ton; this, however, contains sufficient silver to reduce its value considerably below that of the bullion produced by those mines whose ores are poor in silver. The average value of the ounce of bullion obtained from the Flack ores is stated at $13, in coin.

The higher class of ores, carrying considerable silver and combined with lead, zinc, and copper, are reserved for smelting. One lot of nine tons, sold to Professor Hill early in 1869, gave, by assay, 7 ounces of fine gold and 68 ounces of fine silver per ton.

The total production of the mine, since the present management began operations, could not be ascertained. The mine is provided with a small portable engine, of which the cylinder is 9 inches in diameter, that is placed between the two working shafts, but near the western one, commanding both for hoisting. The winding apparatus is operated in the manner already described, by means of belting.

The California lode has of late attracted more attention than any of its neighbors, having, within a couple of years, gained a great reputation by reason of the abundance and richness of its ores. It was discovered several years since, and has been worked more or less since 1864. It is nearly parallel to the Flack, and 300 or 400 feet north of that lode. It is traced for many hundred feet in length. West of the dry gulch, near the Stalker and Stanley claim, the lode is known as the Indiana, and has been sunk upon in various places along its course. The only parties working on that part of the lode in 1869 were three men, who had reached a depth of 150 feet, and were taking out good ore of both classes—that is, for smelting and milling. East of the gulch is the principal claim on the lode, formerly known as that of Stalker and Stanley, but the ownership has lately changed hands. This claim is 300 feet long. East of it the lode has been traced and somewhat prospected for a distance of some hundreds of feet, and apparently continues in its course until it merges into or becomes identical with the Gardner. This is not fully established as a fact, and is doubted by some; but it seems quite probable from present developments.

The Stalker and Stanley claim has been worked to a depth of 475 feet. The main shaft, 50 feet east of the west boundary, had reached that depth in August, 1869, while the east shaft, 130 feet east of the last named, was down 200 feet. Between the two shafts, considerable stoping had been done, but the ground was whole below the 300-foot level.

From the developments thus made the lode appears to possess the characteristics of a well-defined fissure vein. Its course is north 85° east. The dip is slightly to the south, about 85° from the horizon. The walls are smooth and very regular. They are from two to six feet apart, and, in the stopes visited at the time referred to, the whole space was filled with pay-ground. The gangue is a quartzose material, generally resembling that already described as the characteristic filling of the veins of this region. The ore is chiefly iron and copper pyrites, carrying, in bunches or pockets, considerable quantities of galena and zincblende, particularly the last named. There is commonly a seam of first-class ore, associated with a wider belt of milling ore.

During 1869 the ground was unusually productive. According to the statements of the proprietors, not more than one-eighth of all the rock broken in the mine was thrown away as poor; while one ton of ore in ten was said to be fit for smelting. The value of the milling rock was said to be very high, yielding an average of 12 ounces of amalgam to the cord, the ounce being worth about a little more than $13, in coin. According to this, the milling ore yielded about $21 per ton, in coin. The average contents, by assay of over 400 tons of smelting ore sold at the smelting works, was nearly 3 ounces of fine gold and 18 ounces of fine silver per ton.

The mine has not always been in such good fortune. When first opened the surface quartz was taken out about 40 feet deep, and was worked with profit. The shaft then encountered poor ground, which it passed through for 180 feet. It has since been shown that there was excellent ground only a few feet from the shaft, which remained undiscovered because no drift was run toward it from the shaft. At the depth of 180 feet the shaft reached ore-bearing ground that yielded about 7 ounces to the cord, or $12 to $13 per ton. The yield has greatly improved since opening the stopes between the shafts.

In August, 1869, there were twenty-four men employed at the mine, sixteen of whom were stoping. With this force about 30 tons of ore per day were mined and raised. Sinking cost $15 to $20 per foot; stoping $12 or $18 per fathom. A detailed statement of costs could not be obtained; but the mine is said to have yielded a net profit of $40,000 during the summer of 1869.

The mine is provided with a small hoisting engine. Both rock and water are raised in buckets. Four hours per day are required for the engine to raise the water from the mine. From reliable sources the yield of this mine to its owners, from January 1 to August 1, 1870, appears to have been about $75,000, including the product of the first-class ore. This latter amounted to 409 tons, of which the average price paid in currency by the smelters to the mine was $41 90 per ton.

North of Quartz Hill, separated from it by Nevada Gulch, and lying between the latter and Eureka Gulch, is Gunnell Hill, which, since mining first begun in Colorado, has been the scene of active work. Its general trend is east and west, and it contains a number of valuable veins, the general course of which is east and west, or between that and northeast and southwest. The most developed of these is the Gunnell lode, that crops out on the northern slope, not far below the crest of the hill, and which has been worked to a depth of about 500 feet, the opened mines covering a length of nearly 1,200 feet. The general features of this lode are much the same as those of veins already described in this chapter. The vein is said to have been one of the most productive of the country in early days, and it possesses, doubtless, as much merit as many of those that are now being wrought; but, owing to various difficulties and hinderances, some of them quite independent of the intrinsic merits of the property, the work of mining on this lode was suspended some time ago, and is not yet resumed. The principal mines on this lode are supplied with hoisting and milling machinery, and the increasing activity attending mining operations in Colorado will be likely to occasion renewed efforts to bring them into successful and profitable operation. On this hill are several other less developed, but very promising ledges, some of which have been lately opened. Among these is the Fairview, which was first brought into notice in the early summer of 1868. It has since been worked steadily, producing rock of excellent quality, and, it is said, has been a source of great profit to the owners. Its ore is chiefly iron pyrites, yielding from one to two ounces of crude bullion per ton.

On the opposite side of Eureka Gulch, and farther east, is Casto Hill, the location of an actively-worked and promising mine, belonging to the Barrett Mining Company, and opened on what is known as the Winnebago lode. This lode, nearly parallel to the Gunnell, has about an east and west course, dipping vertically, or somewhat inclined to the south. The Barrett Company own 400 feet, and have worked it by means of a single shaft some 300 or 400 feet deep. This shaft has passed through variable ground, having encountered "cap" or barren rock at about 100 feet from the surface, and striking pay ground again 100 feet deeper. The ground is opened by levels and worked by back-stoping. About one-third of the rock broken is said to be good for stamps, and much of the poor rock is selected below ground and left on the stulls. The ore is chiefly iron pyrites, with but a small proportion of copper. The presence of free gold is frequently noticed. The present manager treats all his ore by the stamping process, though some experimental lots of first-class ore have been selected for other more exact methods. One such lot of 24 tons gave, by assay, 4 ounces of fine gold and 4 ounces of fine silver to the ton. The whole mass, when stamped, yields on an average 4 ounces, or $64 worth, of crude bullion to the cord, or about $8 50 coin, per ton. The tailings, after leaving the mill, are said to assay 1 ounce or more to the ton, and are reserved for further treatment. The mine is furnished with hoisting-power, consisting of an engine, the cylinder of which is 14 inches in diameter, and one boiler of adequate capacity. The winding apparatus is the common spool, driven by belting and controlled by a friction-brake. The water is raised in a barrel by this means.

The machinery is set up at the mouth of the shaft, and drives a fan-blower for ventilation, as there is but one shaft. A twenty-stamp mill is set up in a wing of the same building and driven by the power just described. The stamps weigh 500 pounds each and drop 18 inches 28 times per minute. They crush about 2 cords, or 15 tons, per day. Milling operations commenced in July, 1868, and are said to have been conducted with profit. The convenience of the mill to the mine, and the economical arrangement of the whole, afford some advantages for working at a low cost.

Although the mineral veins of Gilpin County are chiefly valuable for their gold, there are some, as has been already shown, that carry a considerable proportion of silver. In addition to these there are a few that are only valuable for silver, and which possess no gold at all, or so little that it is practically unimportant. The development of these silver veins has not progressed very far, but within a year past they have attracted increased attention and are now of growing importance. The Coaley and Gilpin lodes are among the more recent and valuable discoveries of this class of veins. They are situated in Slaughter-House Gulch, a ravine on the north side of Clear Creek, a half mile or more below Black Hawk; they were opened late in 1868.

The Gilpin apparently crosses the ravine with a northeast and southwest course, dipping almost vertically. It is opened by a tunnel on the west side of the gulch, about 200 feet in length. The Coaley crops out about 60 or 70 feet south of the mouth of the Gilpin tunnel. Its course is nearly east and west, and its dip is to the north at about 30° from the horizon. The two veins, therefore, intersect each other. The work done upon them thus far is not sufficient to determine positively whether they are independent veins or one of them a branch of the other. The depth reached in August, 1869, did not exceed 40 feet.

The inclosing rock is of the same gneissic or granitic character which prevails in this district. The walls of the vein, where visible, especially the north wall of the Coaley, are pretty well defined; the crevice is not large in either vein. The gangue is chiefly quartz; the ore consists of galena and zinc-blende, both apparently argentiferous, a little copper and iron pyrites, argentiferous sulphurets, and native silver. The latter, in some selected specimens, is very abundant. Some of the assays of this ore show a very high value in silver, but no gold. Seventy-three tons of this ore, sold for smelting, contained on the average 215 ounces of fine silver per ton.

CLEAR CREEK COUNTY.

The past year was marked by increased activity throughout this county; but the production of silver ore is still limited, not exceeding 2,000 tons per annum. More than three-fourths of this amount was furnished by the Terrible, Baker, Brown, Coin, Snowdrift, Seaton, Belmont, Cashier, and Mendota mines, the remainder being made up of small lots from numerous minor lodes, some of which, however, bid fair to become highly productive under judicious management. In my last report, (page 369,) after showing the aggregate capacity of the reduction works of Clear Creek County to be 12,000 tons per annum, I remarked:

However strong the people's faith may be in the productiveness of the silver mines, there is not at present the least possibility of supplying half that amount. In fact, my boldest expectations will be surpassed if 5,000 tons of good ore are furnished by the mines. Whoever has seen extensive and well-developed lodes, and is acquainted with the production of such, must know that only a limited number of workmen can be profitably employed in a lode, the development of which has been accomplished only to a certain degree. In order to steadily increase the ore production of a mine, it is not enough to start a couple of new stopes; the main object must always be to keep opening the ground ahead, so that there shall be always ore enough in sight to maintain a steady and continuous production. The quantity of ore extracted from a mine reasonably ought to be in direct proportion to the quantity of ore in the reserves; and as there are at this time only half a dozen lodes in and about Georgetown which might be called even partially developed, it is utterly absurd to expect 12,000 tons to be extracted the ensuing year, without endangering the continuous delivery of ores for the following years.

These observations were pronounced unjust when they were first made, and the commissioner was accused of "croaking," and "bearing" the silver mines of Colorado. They can now only be blamed as too liberal in their estimates; and it remains to be seen whether even the production of 1871 will come up to them.

Besides the Terrible, Baker, Brown, and Coin, which have been continuously worked since 1868, the Cashier, Snowdrift, Mendota, and Silver Plume, on Sherman Mountain, and the Belmont and Stevens, on McClellan Mountain, are assuming prominent rank among the productive lodes. The most noteworthy development, however, is that of the Seaton, near Idaho, which has been thoroughly demonstrated to be a lode of large capacity and value. Small lots of very rich ore are now and then reported from the O K, Federal, Magnet, and several other lodes. Little is heard of the Astor, Clift, Comet, Junction, Herkimer, Gilpin, and many other veins, formerly counted among the most promising; and nothing is doing in the Equator, Lily, and Griffith. In some of these mines the workings are in barren ground; in others, the ore is of too low a grade to pay expenses at present rates; others are

idle, awaiting the time when they will be intersected in depth by some of the numerous tunnel companies; and others again have "lost the crevice," which must be hunted for with cross-cuts. As a general thing, it may be said that work with a view to thorough and systematic development is going on only in the Terrible, Brown, Snowdrift, Mendota, Cashier, Seaton, and perhaps the Baker, Stevens, and Belmont. The majority of the other mines worked are merely prospecting shafts or tunnels, or irregular stopes upon occasional pockets or bonanzas. There are several instances of good lodes lying idle by reason of joint ownerships and disagreements. One evil of former days—the representation of stock companies by incompetent superintendents—appears to have vanished at last. So far as I know, the affairs of mining companies in this county are now managed, without exception, by earnest and practical men.

According to statements published in the Georgetown Miner, of September 29, 1870, the total product of the Brown mine, up to that date, was $166,554 55, coin value. The greatest depth from the surface obtained on the mine was 200 feet. There are two levels in the mine, 110 feet apart, one 500 and the other 250 feet in length, making a total of 750 feet of stoping ground. The total product of the Terrible mine, up to date, was $270,000, coin value. In the west portion of the mine 298 fathoms, and in the east portion of the mine 130 fathoms, had been stoped out. The total net profits of the Federal mine, up to date, were $8,151. The total amount of work done on this mine was four months' work for one man. The bullion product of the Baker mine for eleven months, ending September, 1870, was $27,556 97, coin value.

The total production of silver from the county during 1870 was about $400,000, including shipments of ore.*

The Stevens lode, on McClellan Mountain, deserves particular mention, on account of its extraordinary location. An article in the Overland Monthly, for December, 1870, describing an excursion to the summit of Gray's Peak, pictures the wild cañon, across which the Baker and the Stevens mines look at each other, in the following language:

"At this point (Bakerville) we leave Clear Creek, and follow up a tributary known as Kelso. The road now mounts more steeply. The pines and quaking-asps, dwarfed somewhat in stature, come close to us as we ride, as though they were lonesome, and huddled along the road to catch a social glance or word from a passing traveler. The birds and squirrels, so plenty a mile below, suddenly cease to be seen or heard. The peculiar stillness of the upper air makes itself felt. Presently we have emerged from the last belt of timber, and are alone with Heaven.

No, not yet; hundreds of feet above us yet, on the side of Kelso Mountain, are the buildings of the Baker mine. A shanty may mean anything; but a house with a chimney is a sign of permanent habitation. At that warning finger, Solitude gets up and goes Nevertheless, barring the Baker mine, the scene is grand as Nature before the Age of Man. On the right, Kelso Mountain turns to us a rounded, conical form, grass clad. On the left, McClellan Mountain presents a circling ridge, the face turned toward us being as steep and rugged as it can be and not fall over. Whoever has ascended Vesuvius, and remembers how the central cone arises from within the surrounding precipices of a former crater, will comprehend the general position of the parts of this wild scene. But these rocks are not volcanic. The further side of McClellan is sloping, like this side of Kelso; and the further side of Kelso is rough and perpendicular, like this side of McClellan; and the ridge of McClellan does not completely surround Kelso, but

---

*The Miner gives the following estimate, which somewhat exceeds my own calculations. As I do not know its authority or the detailed items of which its aggregates are made up, I quote the declaration without comment:

"During the year 1868 Clear Creek County shipped $91,820 35, coin, in bullion; in 1869 we shipped $400,354, coin, and in 1870 we added $481,354 08, coin, to the supply of bullion of the world. From present indications we anticipate that the shipments for the year 1871 will be over $750,000 in coin, with a strong probability of amounting to over one million dollars."

at its further end soars up into two peaks, and there stops. These two peaks are Gray's and Irwin's; and as we journey they come into full, near view, from behind the head of Kelso.

I am glad enough that the scene is not volcanic. This gray granite, or gneiss, has far greater variety and beauty of form, and gives us delicate shadows. Though it may lack the imperial purples of trachytes and tufas, seen in the distance, it does not offer us their horrid blackness seen near by. Besides, there are dainty grasses and blossoms that sometimes hang by one hand from clefts in the granite, and swing in the wind. Yosemite, Smoky Valley, and Gray's Peak—let the lava people, with their Snake Cañons, Shoshone Falls, and gloomy Dalles, match this granite trio, if they can!

It is lucky that our path doesn't lie up that face of McClellan Mountain. Lie? it couldn't; it would have to stand. No mortal could climb there without wings. But what is that, a thousand feet up the cliff? A house—ye gods! a boarding-house! The glass shows us fragments of a zig-zag trail, interspersed with ladders, where the precipices are otherwise impassable. Now we see at the foot of the cliff another house, and between the two fine lines, like a spider's web, stretch through a thousand feet of air. That is the somewhat celebrated Stevens mine; the men, lumber, provisions, etc., are all carried up, and the ore is all brought down, by means of one of the ingenious wire tram-ways now becoming common in Colorado. How the mine was ever discovered I cannot say—somebody must have "lit on it."

The wire tram-way alluded to in the foregoing description is similar to that constructed some years ago at the Brown mine, and described on page 372 of my last report. Another of the kind was erected by Mr. Kurz for the Griffith mine below Georgetown. In this instance great capacity of transportation was desired; and the tram-way was made in a most substantial and expensive manner, at a cost, I am informed, of considerably over $10,000. Mr. Kurz is said to have planned the tram-way at the Stevens mine, which is light and of small capacity, and cost but $1,180. The use of gas-pipe for the supports saved thousands of dollars in preparing foundations. The self-adjusting arrangement for keeping the cables taut, under alternations of load and of temperature, is likewise ingenious and advantageous. The following account of the works and mine is condensed from the Georgetown Miner:

The tram-way consists of two wire cables, each of which is six-tenths of an inch in diameter, extending from the lower adit on the Stevens lode to the base of the hill, a distance of 867 feet. The supports for the wires are made of gas-pipe, 3 inches in diameter, upon the top of which are wrought-iron T's, securely let into the gas-pipe, upon the top of which T's the wire rope rests. The gas-pipe is set into the rock to a depth of 22 inches, and is securely fastened with lead. The distance from the lower platform to the first support is six hundred feet, the cables resting on their supports with a firmness remarkable for such a long stretch of unsupported rope. We were impressed with the highly ingenious manner of fastening the cables at the base of the hill, which both tightens the ropes and at the same time holds them perfectly secure. Two levers, one end of which is securely bolted to the solid foundation, yet in such a manner as to allow an upward and downward motion of the lever, receive the ends of the cables, which are fastened to the levers near the bolted end, the outer ends of the levers being weighted with rock. This contrivance takes up all loose cable as the ropes may slacken. The tram-way works to perfection. Already there has been 7,000 feet of lumber taken up the cables, and thirty tons of ore lowered to the base of the mountain, demonstrating that the method employed by Mr. Lowe in erecting this tram-way is a successful one. We are surprised when we look at this vast undertaking that no lives have been lost in erecting the work, as the supports have, from necessity, been placed on the brinks of precipices. We were told of many narrow escapes of life made by Mr. Lowe and some of his men, who, in the prosecution of the work, were often in positions far from safe. The Stevens mine is opening splendidly. A substantial dwelling-house has been built upon the mine, seven months' provisions stored at the same place, and work will be actively carried on all winter. Two drifts will be run, each 200 feet in length, and a winze will connect the two. All the ore will be sent to the base of the mountain by the tram-way. There will also be 100 fathoms of stoping done, for which contracts have been let. When the drifts are completed there will be a passage completely through the ridge, and all waste material and *débris* will be dumped on the opposite slope of McClellan Mountain. The Stevens is a fine lode. The crevice is a large one, and carries a good pay streak. The ore being rich in lead, it carries on an average $200 to the ton in silver. It will be recollected by our readers that the ore from this lode took, at our fair, a premium of a silver medal for the "largest and best collection of lead ores carrying the largest percentage of precious metals

Up to the 1st of October the mine has produced, from drifting alone, at a cost of $3,500, forty tons of ore, which will yield $200 per ton. This is an unusually good yield for any mine, and serves to show the character of the property.

This mine is owned by the Crescent Silver Mining Company, a Cincinnati organization. Mr. Theodore H. Lowe, referred to in the foregoing account, is the superintendent.

Among the new mines, not mentioned in my former reports, the Snowdrift and Silver Plume, on Republican Mountain, deserve particular description. I have visited these mines personally, but I prefer to quote concerning them portions of an account of much later date, in the Colorado Miner:

These two mines are situated about 1,400 feet above the level of the creek, and are reached by a good trail, a little over a mile in length. The surface improvements comprise a boarding-house, &c., and also a crushing and sampling mill, at the foot of the hill, run by water power, in which all ores produced will be dried, crushed, sampled, and sacked.

The Snowdrift lode is entered by a short cross-cut tunnel, 80 feet in length; at the end of which a shaft has been sunk on the vein to the depth of 200 feet. Fifty feet below the level of the windlass on the shaft a drift has been run, 180 feet in length; 50 feet below this drift there is another level, 150 feet in length; and 50 feet below this second level is a third level, 130 feet in length. At a distance of 100 feet from the shaft three winzes connect the levels, providing perfect ventilation and opening three blocks of ground, each 50 by 100 feet, for stoping. Comparatively a small amount of work is all that now remains to be done to open up three more blocks of stoping ground, each of which will also be 50 by 100 feet in length. When in this mine we visited all the workings, passed down the shaft, walked through the drifts, and climbed up the different winzes, and, candle in hand, examined and at times measured the width of the pay streak. The crevice is, on an average, 2½ feet in width, and the pay vein will average 10 inches in thickness, of good paying mineral, at times being as thick as 2 feet.

The ore in the Snowdrift is mainly sulphurets, with now and then a small amount of galena, which latter mineral is always rich in silver. The ore from the Snowdrift yields silver in quantities varying from 101¼ to 1,459 ounces per ton.

The owners of this mine, the Trenton Gold and Silver Mining Company, of Trenton, New Jersey, have, with a wise forethought, devoted much of their money and work to the purpose of thoroughly developing and opening their mine, and have now two years stoping ahead of them, and the mine can, if stoping were commenced, now furnish 5 tons of ore per day. This ore would, we feel assured, average $200 per ton.

We were informed that the total cost of all improvements on the mine, including the cost of machinery and dam for the crushing-mill, was not quite $25,000, and in this amount were also included all legal expenses, which have been heavy. The Silver Plume is situated west of the discovery shaft on the Snowdrift lode, which vein it crosses. The lode has been opened by a tunnel, run in on the vein, which tunnel is now something over 400 feet in length, the breast of which being about 175 feet below the surface of the ground. Two air shafts, 50 and 130 feet in depth, provide means of ventilation. The crevice of the Silver Plume is of an average width of 2½ feet, carrying a pay vein that will easily average 1 foot in thickness. The ore is mainly sulphurets, soft and easily mined, with now and then a small quantity of galena, which is also rich in silver. The average value of the milling ore furnished by this mine is fully $150 per ton, although much richer ore is abundant, a lot sent to England a short time since having netted £281 per ton.

This mine is the property of the Snider Gold and Silver Mining Company, of Philadelphia. The company, under the management of Jacob Snider, has, like the owners of the Snowdrift lode, devoted its money and energy to developing the lode, and now have a triangle of ground, 400 feet in length by 175 feet in height, at the base, opened ready for stoping. This ground will average 1 foot of pay ore, which will, as we have stated above, mill $150 per ton. The mine can, when stoping commences, furnish 5 tons of this ore per day, and, at the same time, allow of further developments to be carried on to keep the same amount of ground always ready for stoping.

One of the most remarkable chimneys of ore that we have ever seen is to be found in the Silver Plume lode. This chimney extends fully 50 feet in length on the vein and an unknown distance up and down. Here the ore vein is fully 2 feet in thickness, soft and easily mined, with large streaks and seams of black sulphurets running through the mass of less rich ore. This ore Mr. Snider estimates at about 135 ounces per ton, which estimate is, in our opinion, too low, and should be increased one-third.

My own observations confirm, in a general way, the opinion above expressed as to the promising character of these lodes. If they are

able to keep up such a production as is promised, it will be a weighty reënforcement to the aggregate of Clear Creek County for this year.

An important addition to the mechanical and metallurgical appliances of the county is the new mill of the Stewart Silver Reducing Company, just below Georgetown, which commenced operations about the 1st of September. The works are said to cover 142,000 square feet, and to have required 175,000 feet of lumber, 145,000 brick, and over 6,000 cubic yards of excavation for foundations in their construction. The plans were made by Mr. J. O. Stewart, an experienced millman; and the work is an excellent specimen of the silver-mills of the Reese River type. The machinery, weighing 98 tons, was made at the Eagle Works, in Chicago. Power is furnished by a 100 horse-power steam engine, with two large tubular boilers.

The ore is first passed through a Dodge crusher, of which the mill has two, then dried upon a floor, heated by the escaping gases of the furnaces, then weighed and conveyed to the stamps. There are four batteries, of five stamps each, with high mortars and double discharge, and geared to run separately. The weight of each stamp is about 700 pounds; speed, 80 drops per minute; fineness of screens, fifty holes per linear inch; estimated crushing capacity, 24 tons daily, or about 0.85 ton daily per horse-power developed. Roasting is performed with the addition of salt in six reverberatory furnaces, of the well-known small Nevada pattern. Each furnace requires the attendance of two men. The length of the roasting depends upon the character of the ore. The Terrible ore, which forms a chief source of supply, is roasted ten hours, in charges of 1,200 pounds. In working this material, therefore, the capacity of the furnaces is inadequate to that of the stamps. There is room left in the mill for the erection of four additional reverberatories. After the chloridizing roasting, the ore is cooled, and amalgamated in Varney pans. The amalgamating room is furnished with ten pans and five settlers, and supplied with water-power from a dam on the creek by a race 650 feet in length. The economical defect in this mill is the employment of the old-fashioned reverberatories, which are more wasteful of fuel and labor than either the Brückner cylinder or the Stetefeldt furnace. The daily consumption of wood at this mill must be four cords for the engine, and from one to one and a half for each of the furnaces. Recognizing this disadvantage, Mr. Stewart is engaged in the erection of a so-called Airey furnace, an alleged improvement on the Stetefeldt, to take the place of the reverberatories.

As it is evident that the whole present and immediate future production of Clear Creek County will scarcely suffice to keep these works running at full capacity, the question of success is largely one of commercial competition; and here the Stewart Company has the great advantage of capital, by which it is enabled to buy ores upon assay, and pay for them in cash, before treatment. This system is more convenient to the miners and more profitable for the works; and the rival establishments, doing custom work, find it difficult to keep running in the face of this powerful competition. Hurpeden's German Reduction Works at Georgetown attempted to forestall the danger by cutting down the prices of reduction as early as July, when the following tariff was published:

	Currency, per ton.
1. Surface ores assaying up to $150, coin	$35 00
2. Ores containing but little galena and zinc-blende, assaying up to $150, coin.	40 00
3. Ores containing much galena and zinc-blende, assaying up to $150, coin	45 00
For every $50, assay value, above $150, in addition	2 50

Cullom & Co., of the Swansea Reduction Works, following suit, offered to reduce lead-bearing ores as follows:

	Per ton.
Ores assaying 80 per cent. lead	$25
Ores assaying 70 per cent. lead	30
Ores assaying 60 per cent. lead	35
Ores assaying 50 per cent. lead	40
Ores assaying 40 per cent. lead	45
Ores assaying 30 per cent. lead	50
Ores assaying 20 per cent. lead	60
Ores assaying 10 per cent. lead	70
Ores assaying 0 per cent. lead	80

guaranteeing to return or pay in currency 90 per cent. of the silver, and from 70 per cent. to 80 per cent. of the lead, depending upon the amount of zinc-blende and other deleterious substances in the ores.

Subsequently, I believe, the German works came down as low as $25 to $27 50 for treating a ton of ore. The Stewart Company, however, seems to get the best of the struggle, though it apparently returns less to miners. The nominal charge for treatment is $35; but the company refuses all custom ore, and insists upon purchasing, according to sample assays.

The Airey furnace is not yet completed. It is understood that the proprietors of the Stetefeldt patents consider it an infringement, and that litigation will result from the attempt to run it. A feature of the Airey furnace not possessed by the Stetefeldt is a peculiar lining of the shaft, composed of cast-iron plates, which can be adjusted at will, so as to give a zigzag, instead of a straight shaft. It is useless to speculate upon the value of this feature, or the validity of the whole invention, in advance of actual trial. I sincerely regret that the Stetefeldt furnace was not, by some amicable arrangement, introduced into Clear Creek County. One such furnace would economically chloridize all the ores produced in the county, and a great saving to the mining industry would be the result. Summit County offers, perhaps, a still better field for it.

A striking commentary upon the common statement that high prices of reduction are the reason of the limited production of ore is furnished by the fact that the enormous reductions in price at the principal works of Georgetown did not effect a corresponding increase in the supply of ores. Professor Hill, at Black Hawk, has had a similar experience with gold ores. The fact is, that the production of ore is limited by the condition of the mines, and cannot be doubled at a given signal. No doubt a whole year of low prices will have a stimulating effect, but a permanent increase in production must be effected by systematic opening of stoping-ground; there is absolutely no other way, and until the mines of Clear Creek County can show large actual reserves, all talk of sudden increase in this respect is vain. A few mines are putting themselves in this condition. The list will be increased, I believe, this year, and the mines on that list will furnish the greater part of the ore treated. The small lots brought in for treatment by mere prospectors, when prices are favorable, form a precarious and comparatively insignificant supply. Of course, new veins may be discovered and rich pockets quickly extracted, or even large deposits, like those of the Caribou, in Boulder County, may be rapidly developed; but this cannot be counted upon, especially in a region so well prospected already as the neighborhood of Georgetown. There is no lack of good mines here, but there is great lack of well-opened, steadily-producing mines. It is but fair to repeat that the last year shows solid progress in this respect, and that there is still greater promise for this year.

A noteworthy peculiarity of the operations of the year in Clear Creek County, as in some outlying districts, has been the so-called "tunnel fever." Innumerable sites for tunnel-mouths have been located along the cañons above and below Georgetown; many companies have been organized, and much money has been wasted in attempts to develop, by means of cross-tunnels, the "wealth" of this, that, or the other mountain. Even where such undertakings are commenced in earnest, as many of these were, they are extremely hazardous, and, as a general rule, to be condemned, for the following reasons:

1. A cross-tunnel is likely to be the most expensive of all methods of prospecting. It is run in dead rock, generally hard and costly to excavate, and it cannot furnish ore during its progress to help bear the cost. It is uncertain how much time and money will be required to complete it, and if not completed it is worthless. As for the chance of exposing numerous parallel lodes by running at right angles to the course of a lode system, it can only be said that experience shows few instances of very valuable parallel veins very close together; and it is far better to wait until such a state of things is proved than to run tunnels upon the expectation of it.

2. If a tunnel should cut a lode, it would still be necessary to drift upon it before its value could be ascertained; and if it were thus found to contain ore in working quantity, it would be necessary to open regular stopes for its economical extraction. But regular stopes cannot be opened without a shaft or winze. Either a shaft must be sunk from the surface, or a winze must be "raised" from below, in order to gain the requisite working face or breast. If the former, then the shaft would have been the better means of prospecting from the beginning. If the latter, then the difficulty and expense will be very great; and probably the shaft will have to be sunk from the surface after all, as the cheapest way to get air.

3. The uses of a cross-tunnel for prospecting and transportation of ores are properly incidental. The proper chief function of a tunnel is drainage. Where the cost of pumping is not so great as to call for them, expensive deep cross-tunnels should not be run. Ventilation is often greatly facilitated in this way, it is true, but only where the mines are deep and shafts are already open. Few American metal mines are so deep that ventilation cannot be effected through a proper arrangement of shafts. The cost of hoisting ore from such depths as most of our mines have attained is trifling compared with other mining expenses; and few single mines could save the interest on the cost of a long tunnel by any reduction in this item. The cost of raising large quantities of water, on the other hand, is frequently very onerous; and in many cases a tunnel would be well worth its cost in this respect. But in such a case, the amount of water raised, the proportion of drainage costs to the value of the regular production, and the certainty of continued profitable operations are known elements of the problem; and the question of a tunnel becomes a commercial calculation, very different from a wild speculation.

4. It is evident, then, that deep cross-tunnels should be auxiliary, and not primary works. The history of mining in other countries gives us positive evidence on this point. All the great tunnels in Europe of which I have any knowledge were run principally for drainage, and always to connect with the workings of well-established productive mines. In this country, on the other hand, I cannot recall, out of numerous cross-tunnels, driven primarily for exploration and exploitation, a single instance in which the results have completely justified the meas-

ure. These remarks do not apply to drift-tunnels, run upon the vein, nor to short cross-cuts to find or open a vein.

5. Thus far I have referred to those enterprises only which are undertaken in good faith for prospecting or developing lodes. It is quite likely that a group of mines upon a mountain will, at some time in the course of deeper operations, require and repay the construction of a deep tunnel; but one such tunnel is enough for a large area, and the location of a dozen or a hundred, side by side, is absurd. Moreover, the tunnel should be owned by the mines that need it, and paid for out of their profits; or else it should be constructed upon some agreement or charter binding them to pay for the accruing benefit.

6. The location of cross-tunnels to underrun well-known lodes, owned on the surface by other parties, with a view to extracting ore from them, until the owners can, by sinking upon the veins, establish their identity, is a piece of speculative piracy with which I have no sympathy, and the invariable failure of which, hitherto, seems to me but a just retribution.

7. The sale of "tunnel claims" at exorbitant prices, as if they were in themselves valuable property, is reprehensible. A tunnel claim may be a valuable auxiliary to the owners of the veins which can be drained by it. In and of itself it is the privilege of spending money to cut veins which may belong to other people. As far as blind lodes are concerned the tunnel claim does, indeed, give so many feet upon each vein discovered by the tunnel; but surface explorations would discover many more veins at the same cost than a tunnel will cut; because the surface prospector can go where he likes to look for outcrops, while the tunnel must hold a single course. It is almost as absurd to run a cross-tunnel after blind lodes as it would be to sink a shaft at haphazard in dead rock. The rights attached to a tunnel claim, unaccompanied by surface ownership of known lodes to be pierced, are extremely visionary. The only tunnel right which would be really valuable our laws do not give. I mean the right to exact a royalty from mines benefited by the tunnel. This has been granted by contracts and confirmed by legislation in the case of the Sutro Tunnel in Nevada, an enterprise which, I need hardly say, as it is connected with the largest, deepest, and most productive mines in the country, does not belong in the category I am now discussing. The tunnel royalty was, in Europe, for centuries the privilege of every one who should drive a tunnel not less than 30 feet deeper than any preceding one, so as to benefit an overlying mine.* I do not say it would be wise to make this provision generally applicable to our mines; but this I do say, that in the absence of some such tangible source of revenue, deep cross-tunnels, underrunning only undeveloped or unknown lodes, or lodes belonging to other owners, are gratuitous folly.

8. I do not mean to condemn individual enterprises in this particular district. Several tunnels, such as the Marshall and the Burleigh, have been prosecuted with great energy, skill, and perseverance, and have gone so far as to make the question of their continuance a very different one from the general question of the advisability of such works. Indeed, the best course may be to complete a few of the most advanced tunnels. What I regard as an evil is the multiplication of these enterprises, the diversion of labor from more productive methods of development, and the delusion and discouragement of capital by investments in wild tunneling schemes. The legitimate success of the Marshall or the Burleigh tunnel would be a well-deserved reward to the enterprise and tenacity of its projector; but it would not disprove the views I have

* See my report of 1869, page 196.

expressed on the general subject, nor counterbalance the mass of experience on the other side.

The Marshall tunnel is itself an illustration of some of my criticisms. It enters Leavenworth Mountain about two miles southwest of Georgetown, 930 feet above the cañon bottom, or about 9,382 feet above sea-level. Since March, 1868, it has been run about 850 feet, and cut six well-defined veins. Most of these veins were cut in lean ground, so that they must be otherwise tested, by drifting, before their value can be known. The last vein cut, however, is reported to show a large body of good-looking ore, and it is said that the owners of the tunnel will be reimbursed by this discovery. But the discovery must have cost them a good many thousand dollars, since the cost of excavation alone, by contract, has been from $26 to $30 per foot; and not everybody may expect to be reimbursed in this lucky way. A Colorado paper considers this success a proof that fissure veins are continuous in depth. So they are; and the proof was not necessary.

I repeat that I would not disparage or discourage honest and energetic enterprises now in progress, however strongly I may disapprove of their general method. All rules have their exceptions, and the question of cross-tunnels is one for careful calculation in each case. I do earnestly protest, however, against the tunnel mania, which, I think, is doing great harm to the mining industry of this part of Colorado. It would be strange, indeed, if in a district so rich in valuable lodes so many miles of tunnels should not develop something now and then; but the losses are terribly in excess, and wisdom dictates caution. The same amount of capital and labor will, I am satisfied, in the majority of instances, accomplish more in mining by shafts or drifts upon the veins. It is necessary, also, to warn capitalists that tunnel sites are merely sites for tunnels, that they ought to be auxiliaries of other mining property, and that the value of such property offered for sale must depend wholly on the actual development of the lodes, and not at all on the hypothetical development of the tunnels.

I speak earnestly and at length upon this subject, because the press of Colorado, however desirous of placing facts only before the public, is naturally inclined to applaud all activity and every investment of capital. The over-development of reduction works, which is relatively harmful as being premature, and the over-multiplication of dead work in tunnels, which is largely a positive loss, are more or less stimulated by indiscriminate praise of everybody who seriously undertakes to do any thing. Where so many voices cry encouragement, it is well that one should speak warning.

BOULDER COUNTY.

I have no knowledge of any placer mining in this county. It has become, however, during the past year, the scene of a remarkable development of silver mining in the so-called Grand Island district. This district was discovered, I believe, in 1869, or even earlier; but it was not until June, 1870, that the extraordinary value of its principal lode, the Cariboo, caused it to become the object of special attention and public excitement. I am indebted for detailed accounts of the mines to several gentlemen, principally to Mr. D. C. Collier, of Central City, who visited the district in November at my request.

Grand Island district is some twenty miles north of Central City, and about the same distance west of Boulder City. It is reached from the former place by an excellent road. A correspondent of the New York

Tribune who made the trip gives the following picturesque description of the route:

Leaving Central City in the morning and going down to Black Hawk, we passed up a gulch two or three miles long, and reached the level of the mountain ranges. All the slopes and the mountain tops were once covered with a heavy growth of pine timber, but for several miles around they had been cut clean away for the smelting of ores in Black Hawk and Central. After five miles of travel we passed thousands of cords of wood by the roadside, which had been hauled from the mountain slopes on either hand, and we could see vast blocks taken out of the solid forest. Not many years can pass before all the timber within ten or fifteen miles of Central will be gone, and then ores must be taken to the coal at the foot of the mountains. The road was dry and smooth, and none of the hills were steeper than in ordinary country roads in the States. The broad track indicated the constant travel of the long teams which all day long crowd the way, hauling provisions and supplies to Cariboo and returning with silver ore. Our general elevation must have been about 8,000 feet, while ranges and peaks on the right and left were 1,000 feet higher. We passed a great many cabins belonging to wood-choppers, and in coves, or upland valleys, there were ranches or farm-houses and fields, of more or less extent, where oats, barley, potatoes, and other vegetables had been grown. Further on there were fewer dwellings, but I was surprised to find a fence made of poles along each side of the road, mile after mile, which it seems inclosed claims supposed to be of 160 acres, and which were occupied for pasturage. But these fences must have included a larger area, for high mountains from two to four miles distant made the only limit on that side.

We crossed a gulch known as Gold Dirt, where successful mining had been done, and then we came to the valley of the North Boulder, which presented a scene almost like a New England village, for there were several good residences, a large saw-mill, and several extensive stamp-mills, with lofty chimney-stacks, while the clear and rapid stream runs through a valley as beautiful as can anywhere be seen. Here heavy crops of barley, oats, timothy, potatoes, and all kinds of vegetables were grown this season, and the proprietor, Mr. Rollins, declared that he should raise wheat next year, for he was certain that it could be grown with success. The elevation must be 2,000 feet higher than Mount Washington. He took me into his barn, which would do credit to the best farmer in New York, and it was crowded with hay and oats. He had poultry in large flocks, and fat hogs. Seeing that his work-oxen were sleek and fat, I remarked that they showed evidence of having had grain. He said that, so far from having grain, they had not even had hay, and that they got all their living on the wild mountain grass. His hay is sold at the barn for $30 a ton, to be taken to Central. He showed me some timothy hay grown by irrigation; the stalks were over four feet long. As a general thing, irrigation is not required in the mountains, there being rain-fall enough for small grains and vegetables; still, where practicable, water is used, particularly for grass.

Going out of this valley we came among the mountains again, and yet the line of the road was so skillfully laid that we traveled as easily and rapidly as if we were going through some old settlement in Massachusetts; and the old granite rocks, and the mossy peaks, and the green mountain slopes seemed almost the same as along the Atlantic shore beyond old Salem. Making a turn around a mountain, we saw full before us the vast plains, smooth and gray like the ocean itself, and stretching without a break six hundred and fifty miles to the Missouri River.

Although it was twenty miles down to the foot-hills, the distance did not seem more than five or six, nor did it seem as if there was a descent of 3,000 feet, nor that in a direct line between them there were mountains so steep and inaccessible they had never been trod by human foot. Nothing is more remarkable than the excellent roads which have been made wherever mines have been worked, and they show an enterprise and a bold outlay of capital which is scarcely equaled in any other part of the country.

By a road projected to Boulder City, eighteen miles from Cariboo, Grand Island district will be brought nearer to the plains than Central City.

The town of Cariboo is situated in a deep gulch, less than a quarter of a mile wide and half a mile long, with high mountains on three sides. The altitude of the gulch itself, however, must be at least 9,000 feet, as it is but a few hundred feet below the timber line, which in this part of the mountains is more than 10,000 feet above the sea. The gulch was formerly filled with a dense growth of mountain pine. Cariboo had, in November last, two main streets, one above the other; several steep cross streets; about thirty houses, including a hotel; several boarding-houses, stores, stables, and mining companies' offices, and a population

of one hundred and twenty-five voters. Several smaller settlements and ranches have been established in the little valleys farther down the mountain, where good soil and grass invite the agricultural pursuits for which the neighboring mines have created a market.

The discoveries of silver veins have been made within an area two or three miles square, lying north and west of Middle Boulder Creek, and between that stream and the Range proper. The district is almost entirely covered with a heavy growth of pine.

About a quarter of a mile above the town, and nearly up to the timber line, on the sloping mountain side, is situated the Caribco lode, which has given reputation to this district. The country rock is granite, rendered friable near the surface by the effects of frost. The lode strikes nearly east and west, and has been worked for a horizontal distance of 560 feet. Reports of conflicting and rival "extensions" lead me to believe that the outcrop has not been continuously traced beyond the limits of actual development. During the first 50 feet of sinking, it seemed very questionable whether the mine were a true vein. The crevice pitched to the north at a high angle, presenting no defined walls and often following the strata of the country rock, which was greatly broken, requiring constant timbering. At a depth of about 40 feet the crevice seemed to turn downward, nearly or quite perpendicularly, cutting clearly and definitely across the strata, thus establishing the mine as a true vein. The walls are solid, the south one being well defined and exposed in the underground workings, while the north one is still nearly covered with second and third class ore. The ore vein averages 5½ feet, the vein of first-class ore averaging, from the commencement till November, about 2½ feet.

Later developments (up to January, 1871) indicate that, at the point referred to, the crevice splits, one part pitching south, and the other keeping the previous dip of the vein. In the main shaft—now 140 feet deep—the south crevice has been followed, and has gradually widened till, at about 125 feet from the surface, it is nearly 15 feet between walls. From that point to the bottom of the shaft it gradually narrows to about 5 feet, and shipping ore, which disappeared some twenty feet above, is coming in again. At a depth of 50 feet a horizontal drift, commencing at the main shaft, runs each way, and is, in the aggregate, 260 feet long, connecting with other shafts. From this drift the ore has been backstoped to the surface. At a distance of 100 feet east of the east end of the drift is a shaft, which, at a depth of about 50 feet, struck a fine body of ore, while 200 feet west of the west end of the drift is another shaft 45 feet deep, also revealing a fine vein of ore, making the total distance for which the veins have been opened 560 feet.

The east shaft alluded to is supposed to be on the north branch of the vein. At a depth of 71 feet it shows a vein of first-class ore, 10 or 12 inches wide. A cross-cut is being run from the main shaft, at the second level, 95 or 100 feet below the surface, to cut the north crevice, with the intention of drifting and stoping upon it. This second level, now 180 feet long, shows a vein of first-class ore nearly its whole length, in some places very narrow, but again opening out to 10 or 12 inches in width.

The first work was done on this mine in 1869, when about 26 tons, containing, by assay, $3,217 in silver, were sold to Professor Hill, at Black Hawk. During 1870, about 425 tons of shipping ore were extracted, worth $73,772, or about $173 per ton. This ore was from the 2½ feet of the vein above mentioned as first-class, but from it had been selected three tons of ore yielding an average assay of $5,000 per ton. Were this added to that sold, the average would be upward of $200 per

ton. The lower-grade ores, occupying an average of 3 feet of the vein, have been repeatedly assayed, yielding an average of $60 per ton. The first-class ores are carefully selected, the best laid aside for experimental treatment, and the balance hauled eighteen miles and sold to Professor Hill, while the lower grades are either left standing in the mine or thrown aside to await the erection of works. The average yield of the ore thus far taken out was greatly reduced by the broken character of walls and vein near the surface, which caused the ores to be greatly mixed and prevented assorting. Along the north wall of the vein is a soft gouge, often containing a good deal of hornblende, but this also assays ninety ounces. The gangue is quartzitic.

This mine was sold early in the autumn for $125,000, and the purchasers are rapidly reimbursing themselves. It will be seen that operations are thus far principally confined to its best ores. Estimating the average width of ore above the second level at 2 feet, there are 34,440 cubic feet of ground containing low-grade ore standing in the mine and ready for back-stoping. Between this level and the bottom of the shaft, a depth of forty feet, 32,795 cubic feet are standing, which can be now stoped underhand, but will require another level for back-stoping. This total of 67,235 cubic feet, at the usual estimate of 11 cubic feet of solid vein to the ton, amounts to over 6,000 tons. There are, moreover, some 500 tons of low-grade ore upon the dump, and an unknown quantity is said to be scattered in the dumps of earlier workings, since it is only recently that this ore has been separated at all from the waste-rock.

It will not pay to haul such ore (assaying $60 or less) to Black Hawk for smelting; but it is expected that mills to be erected in the district will treat it at a profit.

Near the Caribou is the Pride of the West, a vein about 4½ feet in width. This mine is not being worked, but shows some very fine looking ore, carrying considerable green carbonate of copper.

The Staten Island is another, which has been opened to the depth of 50 feet, producing specimens of fine ore. Near by is a vein of polar magnetic iron ore or lodestone. The ore has strong magnetic power, picking up as many as three shingle nails in a string.

The Idaho lode, half a mile or more from the Caribou, has a shaft 4½ feet by 10, and 30 feet deep. From this shaft have been sold to Professor Hill the following lots:

	Ounces.	*Coin value.*
3.25 tons, assayed	874	$1,136 20
0.56 " "	103	133 90
6.5 " "	977.5	1,296 75
4.35 " "	522.4	679 12
1.28 " "	618.2	804 66
15.94 " "	3,115.1	4,050 63
Average per ton	195.4	254 10

The ore vein is 5 feet in width. The ore sold is claimed to be an average of 3 feet of the vein. The remaining two feet assay 110 ounces, or $143 coin.

The Boulder County lode is considered one of the most valuable. As it appeared in August, 1870, it presented a 2½-foot crevice, one side of which is rich in gold, and the other still richer in silver. As a greater depth was reached on this lode, the gold seemed gradually to be running out, and the silver increasing in quantity. In much of the ore gold was found associated with large flakes of silver. Specimens had frequently been taken from the mine on which brittle and wire silver are visible

in large quantities, with a smaller sprinkling of gold. The nature of the ore was changing, as the work of sinking progressed, from galena to brittle silver and sulphurets. The highest assay yet obtained from this lode is $12,000 per ton. No ore had yet been treated, for want of a wagon-road from the mine. The road was completed, however, in August, and it was contemplated to send ore at once to the California works below Black Hawk. The lode is situated on Boulder County or Pugh Mountain, (really an extension of Conger or Caribou Mountains.) It is over a mile from Boulder Creek, and three-fourths of a mile below the Caribou, by the new road.

Lower down the mountain, by the roadside, is the Trojan, supposed to be an extension of the Boulder County. It has a shaft 54 feet deep. The vein walls are well-defined and show very plainly throughout. There are 22 inches of ore, carrying sulphide of copper, zinc, lead, and silver, together with a quartzite gangue. This ore contains about $90 per ton in gold and silver, and, after extraction, is piled up to await works nearer the mine. By the side of this ore vein is a crevice 10 inches wide of decomposed material or dirt, which is sold to Hill, at Black Hawk, at from $96 to $126 per ton, currency. The ore vein has never failed since mining was first commenced upon it. The Trojan dips almost vertically, and has been struck at intervals on the surface for 2,000 feet of horizontal course.

The Jo. Thatcher, Grand Island, Sovereign People, Carter, Monitor, Conger, Comstock, Lily of the West, Ohio, Indiana, Kentucky, and Eva, are lodes concerning which the general opinion is favorable. They are said to be from 2 to 5 feet wide between walls; and most of them will be actively developed this year.

SUMMIT COUNTY.

This county is principally noted at the present time for its rich and extensive placer deposits. Commencing at the headwaters of Swan River, extending around to the head of the Blue, and down the latter stream for at least twenty miles, there is almost a continuous placer, carrying gold in profitable quantities. The ground varies in richness, paying from $3 to $30 per day per hand. Less than $5 per day per hand will probably not pay expenses where labor has to be hired. The report of the United States assistant marshal to the Census Bureau mentions but four claims in Summit County as worked during the year ending June 1, 1870, and gives less than $9,000 as the aggregate product, being about $7 per day per hand. The extreme imperfection of this return may perhaps result from the attempt to obtain information at so unfortunate a period as the 1st of June, when the season has scarcely opened, and the miners cannot be found. I am indebted to Wm. P. Pollock, esq., county clerk and recorder, for trustworthy information concerning the operations of 1870, and to Mr. R. J. Burns, of Austin, Nevada, for valuable notes of a personal visit to the county.

Montezuma and Breckenridge are the principal mining towns, the former being the headquarters of quartz and the latter of placer mining. The most productive gulches near Breckenridge are Illinois, Iowa, French, Gold Run, Galena and Georgia, and Buffalo and Delaware flats. Mr. Pollock says that Georgia Gulch alone produced about $3,000,000 from its discovery in 1859 to the close of 1862.

The placer mining season is very brief, lasting but little over five months in the year, yet several claims have each yielded $10,000 per season for several seasons past, and as high as ninety ounces, or $1,575,

has been obtained from one week's run of forty-nine days' work. Several gold nuggets were taken out during last season; one from Georgia Gulch, weighing nine ounces three pennyweights and nine grains; one from Galena Gulch, weighing eight ounces and a half, and one from Lincoln City, weighing nine ounces and a half. The amount of bullion taken out the past season, exclusive of silver, is estimated by the recorder at $350,000. The Georgetown Miner, at the close of the season, said it was nearly or quite $500,000.

The county contains one hundred miles of excellently constructed ditches, many of them having several thousand inches capacity, for conveying the water to work the claims, and declarations are on file for the construction of forty miles more next season.

Two hundred and eighty thousand feet linear measure of placer ground has been preëmpted since the 1st of May, 1870. The greater part of this new ground prospects very well, and gives abundant indications of a large yield with proper management. The claims which have been successfully worked in past seasons, as well as those recently developed, still contain sufficient gold to occupy the miners for years, and, as there is an immense quantity of ground yet unclaimed, and known to contain mineral wealth in quantities, which will repay active and economical working, there is no doubt that Summit County will continue to produce annually increasing amounts of gold.

There are on the county records over four thousand lodes recorded; but very few of them have been sufficiently developed to show their real value, as the owners of most of them are working their placer mines. The majority of the lodes now under exploitation are situated at Montezuma and St. John's, in Snake River mining district.

Montezuma is reached by stage from Denver or Idaho, or by a direct road from Georgetown across the range. The latter road, crossing near Gray's Peak, is one of great natural beauty. It passes through some of the finest scenery of the Rocky Mountains. Beyond the range, it traverses fine timber, and a series of small parks, abounding in cool mountain springs and luxuriant grass. In one of these parks, through which flows the South Fork of the Snake, Montezuma is situated, while Breckenridge is about twenty miles southwest. The road connecting the two places is noted for its lovely meadow scenery and (more prosaically) its excellent pasturage. The Saratoga Ranch, half way between, has a mineral spring—a common occurrence in the parks of Colorado.

The leading mine is, at Montezuma, the Comstock, owned by the Boston Silver Mining Association, Colonel W. L. Candler, superintendent. It is situated on the southwestern face of Glacier Mountain, nearly 12,000 feet above sea-level. Mr. Burns describes his visit to the mine as follows:

Following up the toilsome trail, we reached and entered the lower tunnel of the mine. This tunnel is 150 feet long, from which a level extends 425 feet. We saw masses of ore ready for the hands of the stopers along nearly the entire length of this level. A shaft or winze 70 feet deep connects this level with the lower one, which is 200 feet long, in which we examined the same massive vein loaded with ore. Ascending to the level again, we climbed into a "stope," and observed a large body of ground in which the miners had been busy extracting the abundant ore. A winze of 70 feet also connects the lower and upper tunnels, and in the works of the latter the ore occurred in wide strata. The vein of the Comstock stands nearly perpendicular, and varies in size. At one point it spread out to 8 feet, and at another it contracted to a few feet; but it preserved a general width of 4 to 5 feet. At the point of greatest width there was a stratum of compact ore 2 feet thick upon the head-wall; the same upon the foot-wall; while ore was disseminated through the intervening mass of feldspathic gangue. In the different works disclosing the vein the solid ore ranged from 4 inches to 2 feet thick, and I should judge it fairly averaged 18 inches. The galena was massive, and formed perhaps one-third of the ore. Zinc-blende, and iron, and copper pyrites occur also

abundantly; and in the deepest works silver glance and brittle silver are not uncommon. Handsome crystals of heavy spar are of frequent occurrence. Tests of the value of the different kinds of ore ranged from $40 to $400 per ton. All the work in the mine—the spacious clean-cut tunnels and levels, and the well-timbered winzes and stopes—indicated the most skillful management. Captain Ware informed us that it was part of his project to open the mine by a tunnel 450 feet below the present lowest tunnel, which will be 550 feet long, and will cut the vein nearly 700 feet from the surface. If this plan is carried out it will open avenues to bodies of ore that will require years to extract. The amount of ore ready for reduction and piled at the mouth of the tunnel, in the ore-house near by, and at the mill, was estimated at 3,000 tons. And if occasion should require it, Captain Ware told us he could easily set fifty men to stoping ore.

The ore will be delivered from the mine to the mill over a tramway about 2,200 feet long. This tramway, which was building under the direction of Captain Ware, will connect with the present lowest tunnel, and ultimately with the projected deep tunnel. Not only ore, but the miners and all supplies for the mines, will be carried over the tramway. It will be capable of discharging 100 tons of ore from the mine to the mill daily.

The reduction works of the company are of a very inferior character, unworthy of the splendid mine, and wholly inadequate to the treatment of the ore. They consist of a crusher and rollers, a small concentrator, and a reverberatory and a cupola furnace.

According to later reports, the mine has about 1,000 feet of stoping-ground, and can work seventy-five miners underground. Sixty tons of ore can be raised to the surface daily, and delivered at the mill by the tramway at a cost of about $3 75 per ton for mining and 20 cents for transportation. The company has reduced during the summer 50 tons of ore, at a reduction cost of about $22 per ton. The average yield was $100 per ton. The imperfect apparatus was capable of treating only the galena ores—about one-fifth of the vein material; the remainder, containing from 30 to 40 ounces of silver per ton, being thrown aside. It is proposed to construct a new mill, combining amalgamation with smelting, so that all the ores can be reduced.

The Chenango Company owns the Favre, Chloride, Coley, and G. T. Clark—all highly-esteemed lodes. The mine is in Glacier Mountain, about a quarter of a mile farther down the cañon than the Comstock. A tunnel, about 460 feet long in December last, had cut through two veins, assaying about fifty ounces of silver per ton. A short distance below the mine the company has a mill, which is idle, and reported to be of no value.

The Sukey lode, belonging to the Sukey Silver Mining Company, Hon. J. T. Lynch, superintendent, is opened by two tunnels, one 260 feet, and the other (150 feet above) 96 feet long. One hundred and eighty feet above the upper tunnel is the discovery shaft, 40 feet deep. The vein is from 4 to 6 feet in width, with an ore-streak of 20 inches to 3 feet. The ore exhibits very rich specimens, but the great bulk of it is of a low grade, the average point being between $35 and $40 per ton. The capacity of the Sukey for the production of this grade of ore is very great. The company owns a small mill, 30 by 80 feet in size, and containing five stamps, one roasting-furnace, and two Blatchley pans for amalgamation. It is run by water-power. Seventy tons, reduced during the summer, averaged 60 ounces of silver per ton, the cost of reduction $22 to $24 per ton. It is proposed to increase the capacity of the mill to fifteen tons per day, which will reduce the cost to $15 per ton.

The St. Lawrence Silver Mining Company owns the Silver Wing and Napoleon lodes, on the north face of Glacier Mountain, a few hundred feet above the South Fork of the Snake. The former is tunneled 30 feet, showing a vein 4 feet wide between walls, with an ore-streak varying from 10 to 20 inches, and carrying by average assay 35 ounces of silver per ton. The Napoleon is tunneled 65 feet, with a crevice similar

to the Silver Wing, and assaying about 60 ounces of silver per ton. During the past summer the company has been completing its mill, a very good one, containing a twelve-stamp battery, and two pans for amalgamating. Arrangements are said to have been made for the erection of a Stewart & Airey furnace for roasting and chloridizing.

The Old Settler lode, owned by Black & Milner, is tunneled 260 feet, and shows an ore-streak 2 feet wide, composed of lead, zinc, gray copper, and iron sulphurets. Assays range from 20 to 100 ounces of silver per ton.

The Dysart lode, owned by Geo. W. Packard, has a shaft 30 feet deep, showing a vein 4 feet wide between walls, and an ore-streak of 18 inches. Assays give from 30 to 100 ounces of silver per ton.

The Umpire lode, owned by Sharrat & Morrow, has a shaft 20 feet deep, showing a vein 4 feet wide. Assays give from 20 to 60 ounces of silver per ton.

The North Star lode, owned by Lynch, Pratt & Co., is 4½ feet between walls, with 12 inches of ore, composed of lead, zinc, and copper sulphurets. It assays from 80 to 240 ounces of silver per ton.

Guibor's extension of the Coley lode, owned by Guibor & Co., has a a shaft 60 feet deep, a vein 4 feet wide, and an ore-streak of 20 inches, assaying from 50 to 200 ounces of silver per ton.

The Tiger lode, owned by Lynch, Pratt & Co., has a shaft 20 feet deep, a vein between walls 6 feet wide, and two pay-streaks, one next the north wall 10 inches wide, (heavy galena,) assaying 100 ounces of silver per ton, and the other next the south wall, 6 inches wide, assaying from 1,000 to 2,500 ounces of silver per ton. The intermediate rock assays from 16 to 30 ounces of silver per ton.

The Walker lode, owned by Fix & Hewitt, is opened by a shaft and tunnel, and worked by the latter, which is in 60 feet. The vein is 2 feet wide, and the pay-streak about 4 inches. An assay from several tons of ore reduced in the Sukey Company's Mill gave 206 ounces of silver per ton.

The Chatauque lode, owned by Teller & Bull, has a shaft 32 feet deep, and an ore-vein 6 feet wide. About 100 tons of ore are extracted, all of which contains more or less grey copper, &c. Four samples taken from the pile—two from the inferior and two from the best quality—were assayed by Hon. J. T. Lynch, with the following result:

No. 1, $41\frac{1}{6}$ ounces of silver; coin value, $54 08 per ton.
No. 2, $22\frac{1}{4}$ ounces of silver; coin value, $29 12 per ton.
No. 3, $716\frac{1}{8}$ ounces of silver; coin value, $931 84 per ton.
No. 4, 672 ounces of silver; coin value, $873 per ton.
Making an average of $363\frac{3}{20}$ ounces of silver per ton.

The average of 34 assays, made by Mr. Lynch, agent of the Sukey Company, during the summer, from various lodes in this vicinity, as shown by the assay book, was $143 35 per ton.

Each of the mines above named has ore on the dump ranging from 20 to 200 tons; and there are many other lodes in the district which contain ore in paying quantities. It is believed that as soon as the late improvement made by Mr. Stetefeldt, of Nevada, for roasting and chloridizing ores, is introduced into Snake River district, which is contemplated next summer, it will be one of the most important silver-producing districts in Colorado.

There are are numerous other lodes in all stages of development in other portions of the county, many of them exceedingly rich. The Bullion and Incas Mining Company, near the head of Clinton Gulch, in Ten-Mile district, owns some very good veins, and has run a tunnel 800 feet,

passing through several lodes which are said to "prospect" very handsomely. A large number of lodes of decomposed quartz, containing free gold, have been discovered near the sources of our placer mines, and will, it is hoped, be thoroughly developed and practically worked next season. The lodes of Summit County have been neglected in the past, but the coming year will witness an era of development, both in placer mines and lodes, never before known; and it is expected that the yield of the precious metals will double that of any previous year since the settlement of the county.

LAKE COUNTY.

I have never personally visited this county, nor have I received any direct and detailed information concerning its mines during the past year. The county seat is Granite, a small town pleasantly located on the eastern bank of the Arkansas River, and in a district characterized by the occurrence of free gold in quartz veins. Many lodes have been located, and a few are worked with energy. Among the most prominent enterprises is that of the Yankee Blade Mining Company, on the lode of the same name. About half a mile above the town this company has a 20-stamp mill, in which the ore is treated by battery amalgamation, blanket-sluices, and pans for tailings. The mill is run by steam in the winter, and by water-power in the summer. During the winter of 1869-'70 the quality of ore treated appears to have been high. According to a report in the Georgetown Miner, the average yield from a lot of 40 cords was 23½ ounces of gold per cord. At midsummer, 1870, second-class ore was under treatment, yielding (on the same authority) an average of 8 ounces per cord. Major H. Hill is superintendent. The product of the mill for the year ending June 1, 1870, was about $60,000. Thirty men are employed, at the average wages of $75 per month.

The Treasury Mining Company has a 15-stamp water-power mill, which was running last summer. Hayden & Son have a 9-stamp water-power mill, which has been running during a portion of the year. The product for four months is reported to have been about $7,500.

The placer mines of Lake County have been hitherto more productive than its quartz veins. The product from thirteen claims, reported by the assistant marshal to the Census Bureau, for the year ending June 1, 1870, was a little over $60,000. These claims employed sixty-seven men for an average period of six months, at the average wages of $60 per month, and gave an average yield of $5 81 per day per hand. The principal claims were those of the Pilot Mining Company, the Graff Mining Company, and Inman, Dyer & Co.

PARK COUNTY.

The only quartz-mining company at work in this county of which I have any information is the Pioneer, which was at work during part of the year, and is reported to have produced $40,000 in four months. The placer mines of the county have yielded perhaps as much more, paying rather less than $3 per day per hand for a season of say five months.

CHAPTER X.

WYOMING.

The most promising of the mineral resources of this Territory must be confessed to be the immense coal deposits, which extend for nearly three hundred miles along the line of the Union Pacific Railroad. As these have been made the subject of special investigation and report by geologists in the service of the Government, I shall not speak of them at length. The coal is used in the locomotives of the Union Pacific road, and upon the Central Pacific for some five hundred miles west of Omaha. On the latter road it is reported that a ton of 2,000 pounds will run an engine, on the average, seventy-five miles. The average consumption of the engines on the Pennsylvania Central is one ton to every forty miles. These data could not fairly be compared without more information as to weight, grade, and load, but they must be considered, after every allowance has been made, as extremely favorable to the Wyoming coal. This coal certainly stands in the front rank among those of the Rocky Mountains, and ahead of many western coals, in its general heating properties, its freedom from sulphur, and its resistance to the disintegrating action of the weather. It is indeed claimed to be better than Lehigh coal, ton for ton, for making steam, for domestic use, and for gas manufacture. It gives little waste, ash, or clinker, kindles easily, and burns freely. It is asserted to make 10,000 feet of gas per ton, Pittsburg coal yielding about 8,500. Evidence as to its fitness for metallurgical uses is both meager and contradictory. The different mines now open seem to furnish different qualities of coal in this respect. Some of the coal, from Evanston and elsewhere, is said to coke well. Wyoming coal was tried last summer by the Union Pacific Company, in one of their cupolas at Omaha, for smelting cast iron, and found to answer the purpose better than anthracite, adding, it is said, to the fineness of grain and the toughness of the iron. The proportion of metal and coal were about the same as with anthracite, and the time required for the smelting process also about the same. In the hills north and east of these vast fields occur layers of clay, iron, and stone, yielding about 30 per cent. of metallic iron, remarkable for the large amount of lime it contains, thus obviating the necessity of using other flux, and leaving the ore in an unusually porous and fusible condition by means of the expulsion of carbonic acid gas in such great quantities. A few miles farther east deposits of magnetic ore have been found, and on the Weber River, a few miles west, the same ore has been discovered in great quantities. The existence of unlimited quantities of coal and iron, in such close proximity, promise to make this region the seat of a great iron manufacturing industry in future years. Its natural advantages, combined with the requisite transportation facilities furnished by the Pacific Railroad, are attracting the favorable notice of western capitalists, and it is probable that extensive operations will be undertaken within the next few years for the development of its vast resources of coal and iron.

The gold-mining industry is confined principally to the Sweetwater District, of which an extended account was given in my last report. I regret to say that the progress achieved last year in this district was not satisfactory. Operations received a severe discouragement from the failure of two mines which were so managed in 1869 as to create

large expectations. A good ten-stamp mill was placed upon each of these mines, and they were so manipulated by speculators as to sell at high figures, in preference to more valuable properties. These two mines are now virtually abandoned, and the mills upon them have been lying idle during the entire season. The natural result of the failure of enterprises so prominently before the public has been a distrust that makes capital very slow of investment, even in mines that would yield good returns. The claims of this region are mostly in the hands of first owners, men who have not the means to put up mills and put their mines in proper working condition. The greater number of the claims in the country which were worked in 1870 were operated by this class of men, to the extent of their ability, for the purpose of prospecting and developing them. The lodes which do not promise well have generally been deserted. Nearly all the rock crushed during the past year was furnished by three or four claims.

The district contains six ten-stamp mills, one six-stamp mill, and three twenty-stamp mills. Of two additional ten-stamp mills, one has been dismantled, and the power has been applied to run a saw-mill, and the other was destroyed by fire late in the season.

The express shipments of gold for 1870 amounted to about $80,000. The amount leaving by private conveyance is unknown; but I presume it was small, as this item is only considerable where express charges are high, and where placer mining produces large amounts of gold. I think that the product for the year may be put at $100,000.

For notes of operations, etc., I am indebted to Mr. Bolivar Roberts, Mr. R. K. Morrison, and other residents.

The best mines and claims, so far as they have been tested by the actual working and milling of the rock, are the Cariso, the Miners' Delight, the Young America, the Carrie Shields, the Sowles & Perkins, and the Buckeye lodes. The Cariso and Young America are situated a few hundred yards from the village of South Pass, and are but a short distance apart. The shaft upon the former is now 180 feet deep, and good machinery for hoisting is erected upon the mine. Two levels have been run northeast, to a distance of 50 feet each, at the depths of 90 and 140 feet respectively. Three levels have been worked southwesterly, from 30 to 60 feet. Good paying quartz was extracted from all these levels. The lode pitches south at an angle of about 45°, to a depth of 150 feet, when it becomes vertical. Water comes into this mine at the rate of about 250 gallons per hour.

The Young America mine has a shaft 85 feet deep, from which two levels have been worked to a distance of about 60 feet, at the depths of 60 and 85 feet respectively. The quartz is of good quality, and the vein is from 1 to 4 feet wide. Hoisting works of a superior pattern are erected upon this mine. The ten-stamp mill belonging to this company was destroyed by fire, the work of an incendiary, on the night of the 11th of November, 1870, which has caused a temporary suspension of operations.

The Carrie Shields lode is working to a depth of 80 feet. The vein is from 18 inches to 3 feet wide, and rich.

The Miners' Delight mine has been worked from an incline following the ledge, to a depth of 95 feet. The company is sinking a vertical shaft from which to work the mine, and is at present driving a cross-cut to the lode, at a depth of 116 feet. The sinking of the shaft still goes on. The lode is from 2 to 6 feet wide, and pays from $35 to $150 per ton. This mine and the Cariso have yielded the richest ore yet produced in the Sweetwater country.

The Sowles & Perkins lode shows a vein about 3 feet wide of paying ore. The shaft is 90 feet deep.

The Buckeye lode is about the same in width as the Sowles & Perkins. The company is now sinking a vertical shaft from which to work this mine. The shaft, which is now (January, 1871) 130 feet deep, is located so as to cut the lode at a depth of 150 feet. They have now reached 130 feet.

There are a number of other lodes which promise well, but which are in the hands of parties who have taxed themselves severely to develop their properties thus far, and who lack the means to increase the scale of their operations. As these lodes have not been tested by the repeated and continuous milling of the ore raised from them, they must be passed by for the present; another year will, no doubt, prove the quality of a number of them.

The Sweetwater mines of gold-bearing quartz, so far as they have been worked, are comprised within a belt of country about eight miles long and less than one mile wide, running from southwest to northeast. Rich float-quartz has been picked up, and lodes that prospect well have been discovered outside of these limits; but the working of such lodes and the formation of new camps has been prevented, mainly by incursions of hostile Indians. The extent of the undeveloped lodes of the country is entirely unknown, and the gold-producing capacity of those which have been worked most is but very imperfectly developed.

The population of Sweetwater County, by the census of 1870, was 1,916. About half of this population belongs to South Pass and Atlantic Cities, Miners' Delight and vicinity comprising the mining district.

Wages for good laborers are from $3 50 to $4 per day; wood is $4 per cord; lumber, $35 to $50 per thousand feet; flour, $7 to $8 per hundred pounds; potatoes, 6 cents per pound; sugar, 20 to 30 cents coffee, 35 to 60 cents; butter, 50 to 75 cents; bacon, 35 cents; lard, 40 cents; fresh beef, 15 to 25 cents; and case goods, $7 to $15 per case.

PART II.

METALLURGICAL PROCESSES.

CHAPTER XI.

THE TREATMENT OF AURIFEROUS ORES IN COLORADO.*

It is proposed to describe in the present chapter the processes and apparatus generally employed in Colorado for the treatment of gold ores, leaving out of consideration the operations of mining proper.

1. In the mine there is generally no further separation than that which the miner effects in drilling and blasting, by endeavoring to obtain the pay ore distinct from the barren gangue. All the rock thrown down is generally hoisted to grass; but the two classes are, as far as practicable, kept apart. There is no sorting of the ore underground, according to the size, richness, or mineralogical composition of the fragments.

2. Above ground the rock is roughly sorted, with the aid of a limited amount of spalling, into two classes, waste and mill rock. The waste amounts, generally, to one-half or two-thirds of the whole. This sorting is often accompanied with a selection of the larger masses of pure ore, rarely more than 10 per cent. of the mill rock. The ores consist principally of iron and copper pyrites, frequently associated with other ores of copper and galena, and zinc-blende. The gangue is a mixture of quartz and feldspar.

The further preparation or concentration of the ores is, in most cases, intimately connected with the extraction of the free gold. It consists in crushing by means of stamps, and simultaneous amalgamation, after which the tailings, in many cases, are at once discharged into the rapid creek. Most frequently, however, by various methods, the heaviest portions, with a part of the gold which has escaped amalgamation and of the quicksilver lost by the apparatus, are more or less completely recovered.

I. THE CRUSHING IN STAMP-MILLS.

ARRANGEMENT OF THE BATTERIES. (Figs. 1 and 2.)

These have universally a wooden frame and a cast-iron mortar. The stamps, shaft, and cams are of iron.

As a rule, the ground is excavated down to the not very distant bed-rock. Upon this are firmly laid, let in, or set in masonry, a number of longitudinal sills, *a*, and upon them the cross-sills, *b*, about 1 foot square and 10 to 14 feet long, and corresponding with the number of stamps. At right angles to these is the battery-log, *c*, 22 to 30 inches square, of the best pine, the upper surface of which is at the level of the mortar-bed.†

Upon the battery-log the posts, *d*, are erected. They are likewise of pine, 18 to 20 inches wide and 10 to 12 inches thick, and about high

---

* A series of articles on this subject, from the pen of Mr. Albert Reichenecker, of Central City, Colorado, recently appeared in the German *Berg-und-Hüttenmännische Zeitung*. With the permission of the author, who has also furnished me with original drawings to illustrate this chapter, I translate a large portion of his treatise. It has seemed best not to alter or interrupt Mr. Reichenecker's text; and I have, therefore, put my own observations and comments in the form of foot-notes, with my initials.—R. W. R.

† The battery-log or mortar-block here described is not so good as the vertical timbers used for the same purpose elsewhere, and to some extent in Colorado also.—R. W. R.

enough to reach to the upper end of the stamp when it rests on the mortar-bed. The posts are maintained in their upright position by the mortised and bolted guides, *g*, g^1, above and below, 8 to 10 inches deep by 7 to 9 inches wide, and by the stays and braces, *e*, *f*, on the side of the discharge.

The lower part of the mortar, *h*, is a solid casting, provided with flanges, through which it is bolted to the battery-log. Two longitudinal sills, *i*, 6 to 8 inches thick, not quite so high as the cast-iron mortar, but reaching down somewhat over the battery-log, prevent a side movement of the mortar. Frequently the above-mentioned bolts are omitted; but there is cast on each side of the mortar-bed, through its whole length, a flange about two inches wide, on which these sills are firmly laid.

The upper guides, g^1, lie not more than 1½ foot below the upper end of the battery-posts, and the lower guides as low as the stamp-head will permit. This brings them about 6 or 7 feet apart. The guide proper consists below of a cast-iron thimble, g^2, consisting of two halves with flanges, which is let in between the guide-timbers, to the rear one of which it is bolted through the flanges. Above, the guide consists of two 3-inch planks, cut out to fit the stems of the stamps, and bolted to the rear timber, which is here the only one. Wooden wedges, driven between the planks, keep them at the proper distance apart to give play to the stamps. Frequently the lower guides are arranged in the same manner, but with both front and rear timbers.

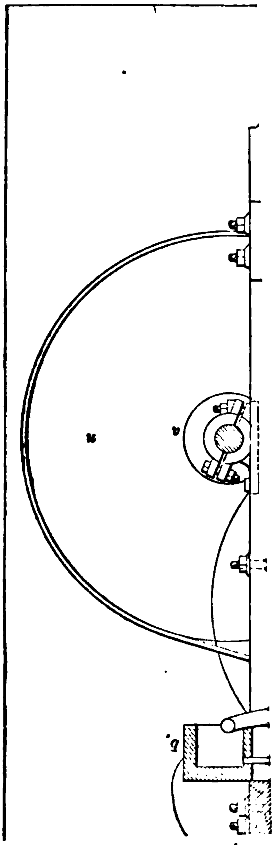
As has been remarked, the battery-box is, up to about 3 inches below the discharge, cast in one piece with the mortar-bed.* The latter is horizontal, 3 to 4 inches thick, and provided under each stamp with a recess about an inch deep, in which is set the cast-iron die, *k*,† 3 to 4 inches high, slightly decreasing in size toward the top. The upper surface of the die is greater by perhaps half an inch in diameter than the shoe of the stamp. The upper part of the die is of chilled iron; the lower part, say one inch of the height, of softer iron, fits into the recess in the mortar-bed, and is generally circular, though sometimes polygonal in section. The die, like the shoe, can be easily changed when worn out, and in this way the destruction of the mortar-bed is prevented. The iron walls of the battery-box are 1½ to 2 inches thick at the bottom, and decrease in thickness somewhat, while the box itself widens a little toward the top.

The plank housings, *l*, are fastened to the longitudinal sills, *i*, and neatly fitted at sides and bottom. They usually reach to the lower guides, and completely inclose the battery-box, with the exception of the

---

*The latest California pattern of mortar is much higher than this, having bottom and walls cast in one piece. There are several decided advantages in the high mortars. I know of none possessed by the low ones, except greater cheapness of first cost and freight.—R. W. R.

†In the stamp-mill attached (for dry crushing) to the reduction works of Huefeden & Co., at Georgetown, a single solid block is used, instead of a number of dies. This is the form adopted in Germany and Hungary. It permits the use of both sides, by simply turning over the bed when the upper side is worn by the stamps into depressions, and it is claimed that a considerable gain in economy results. One objection that occurs to me is the necessity of turning or changing the whole block when it happens to be worn away in a single spot, though the remainder may still be serviceable. It is doubtful, however, whether this counterbalances the advantages of simplicity and cheapness and the ease with which the whole can be removed at one operation, to clean out the mortar. A more serious objection, perhaps, is the fact that such a die-block wears in circular depressions, which may diminish the effectiveness of the blow of the stamp; while the projecting circular die presents always a prominent surface, clears itself of pulp, and thus brings the quartz always between the iron faces of shoe and die.—R. W. R.



r . . . my last report, and a chapter in the present volume, further on.—R. W. R.

shoe and die.—R. W. R.

feed-slit, *r*, and the discharge, *s*. The bolts, *m*, hold the housings firmly to the posts, and wedges driven between them and the guides press them closely to the sills below.

Each battery contains usually four or five, now and then three, seldom six stamps.

The iron stamp consists of four parts: the head, the stem, the collar, and the shoe. These are all cylindrical in form.

The cast-iron head, A, has the same diameter as the shoe, and is 18 to 20 inches long. Its lower surface is provided with a conical recess 6 to 7 inches deep, to receive the shank of the shoe, and a similar recess is bored in its upper surface for the lower extremity of the stem. The interior end of each of these recesses is intersected by a mortise passing through the stamp-head, so that by driving a wedge through this opening the shoe or stem may be loosened and forced out when necessary. In some cases the lower end of the head is turned down in the lathe to receive a wrought-iron ring, ¾ to 1 inch thick and 1½ to 2 inches high.

The wrought-iron stem, B, has a length of 9 to 11 feet, and varies in thickness, according to the weight of the stamp, from 2 to 3 inches. The lower end is turned to a somewhat conical form to fit the recess in the top of the head. The upper end is also turned down a little for some distance to permit the collar or tappet to be slid over the stem to its place. In some cases the stem has a screw-thread in the neighborhood of the collar, and the latter has a place for a key, by means of which the collar can be screwed up or down on the stem, and then keyed fast in the desired position.

The collar, C, consists of a hollow cast-iron cylinder, 5 to 8 inches in height, 2½ to 3 inches thick below, and somewhat conical above. The interior is turned to fit the stem, or with a screw-thread. The lower working surface is sometimes protected with a steel ring; but ordinarily the lower, cylindrical part of the collar, about 2 inches high, is merely made of chilled iron.

The shoe, D, is always of cast iron, the butt, up to within ¾ of an inch of the shank, being chilled and the rest cast in sand. The shank is 4 to 6 inches long, having below half the diameter of the butt, and contracting conically upwards, as shown in the engraving. The diameter of the shoe varies between 6½ and 10 inches, the ordinary limits being 7½ and 9 inches.

In setting up the stamp, the stem is driven into the head, the collar either simply slipped over and driven down or screwed on, and then keyed fast. The shoe is set in the mortar under the stamp, the shank is surrounded with thin wooden wedges, pointed upwards and kept in place with a string. Then the stamp is allowed to fall, and the shank wedges itself into the head with sufficient firmness to remain fixed. With every subsequent fall of the whole stamp the several parts tend to wedge more tightly into one another. The only exception is the collar, in case it is screwed on.

The weight of the stamp varies between 300 and 750 pounds.* Most

* According to Mr. Hague, the Colorado stamps, as a general rule, are heavier, run more slowly, and with greater fall than is usual in the mills of California and Nevada. Some of them weigh 900 pounds each; and although the mills of most recent construction have generally adopted a 500-pound or 600-pound stamp, the average is probably somewhat higher than that at present. Personally, I incline to the opinion that 600 pounds will be found a practically convenient weight, permitting on one hand a high rate of speed, and securing a sufficiently powerful blow with a moderate fall. As regards speed of running, see remarks in my last report, and a chapter in the present volume, further on.—R. W. R.

frequently it is between 400 and 600 pounds, and so divided that the weights of head, stem, collar, and shoe, have about the proportion of 5: 3: 1: 2. All the stamps of a battery have the same weight. About 9 pounds is the weight per square inch of crushing surface.

The sum of the working surfaces of the shoes is to the mortar-bed about as 1 : 2¼. The interval between the shoes and between those at each end and the end of the mortar is ¾ to 1¼ inches.

The cam-shaft (Fig. 1, *n*) is generally of wrought iron, and has half the diameter of the shoes. It is always rigged (in Colorado) with double cams. It rests on journals attached to the battery-posts, generally on the side of the discharge. Its center is 7 to 9 inches from that of the stamp-stem. It is generally placed about half way between the upper and lower guides, though there are departures from this practice. In large mills there is a cam-shaft for every, say, twenty stamps.*

The cams (Fig. 1, *o*) are of cast iron, have a T-section, and are curved to the involute of a circle.† The two cams of each pair are cast together on a ring 5 to 6 inches long, and 1½ to 2 inches thick, which is slipped over the cam-shaft and keyed fast. The working face of the cams, 2 to 3 inches wide and 1 to 2 inches deep, is chilled. In some cases the two cams are screwed instead of cast to the ring, or each cam is cast with half a ring, and the two halves are screwed together. In this way the replacement of a broken or worn-out one is greatly facilitated.‡

The lift varies between 10 and 18 inches. It is usually 11 to 14 inches, representing a length of cam-curve of 18 to 21 inches. The difference between the theoretical maximum lift of the cams and the fall of the stamp is quite considerable, amounting with new shoes and dies to 8 to 10 inches. The lift is not changed by raising the collar as the shoes and dies wear away, since this, in most cases, in consequence of the manner in which the latter is fixed on the stem, would be a work of difficulty.

Power is obtained sometimes from overshot water-wheels, (more seldom, turbines;) and in lack of the necessary water, from steam-engines of every kind. The steam pressure averages three to four atmospheres, and is produced in flue-boilers and tubular-boilers, the universal fuel being wood. The power is generally transmitted (from a steam-engine directly, from a water-wheel through spur-wheel gearing) by means of a belt and pulleys (Fig. 1, u^1) to a shaft u, and from this through two spur-wheels vv^1 to the cam-shaft.

Auxiliary arrangements.—To facilitate operations around the upper part of the battery frame, a shelf or scaffolding is laid on one or both sides, usually a little above the lower guides, (Fig. 1, *p*.)

As a special aid in "catching up" the stamps, a wrought-iron lever is sometimes employed, (Fig. 2,) having a hooked support with an eye at the upper extremity. This eye slips over a bolt-head in the upper guide-timber, and the fulcrum-bar or support then hangs vertical. At the highest point of the stroke the toe of the lever is inserted under the collar, and the latter is lifted just out of reach of the cam—a position in which it is kept as long as desired (for repairs or other purposes) by means of a prop from the lower guide-beam. When the lever is not

* It is now common in good mills to gear each battery of five stamps with separate cam-shafts, pulleys, &c., so that the stoppage of one battery would not hinder the rest. In this way, different batteries may be run at different speeds—an important matter when the material to be crushed varies in character.—R. W. R.

† Slightly modified at the end.—R. W. R.

‡ Some good millmen prefer single cams, and a higher rate of revolution for the shaft. I do not remember seeing such in Colorado.—R. W. R.

used, it is necessary in order to hang up a single stamp to stop the whole battery, remove the housing on the feed side, and pry up the stamp to the desired point, where it is held, as before, by a prop.

The battery-water is supplied to the mortar through a wooden trough (Fig. 1, q) attached to the frame above the lower guides, and provided, opposite each stamp, with a pipe which terminates over the guide-thimble, g^3, so that the escaping water first cools this cast-iron thimble, and then, running down the stamp, enters the mortar. But rarely is the supply of water so arranged as to be separately regulated for each battery. In winter the battery-water is warmed by allowing the exhaust steam of the engine to pass through the trough or box conducting it, or an iron pipe is used instead and passed through a furnace.

The rock is charged through the housing, by means of a slit (Fig. 1, r) extending the whole length of the battery, about 4 inches wide, and vertical above, but inclined below at an angle of 48° to the mortar, so that the rock rolls in against the upper half of the stamp-head, when the latter is at its lowest. The interval between the side of the mortar and the stamp is here 3 to 4 inches. The sides of the charging-slit, r, are lined with strong sheet-iron.

The larger fragments of rock are frequently spalled by machinery. For this purpose crushers or stone-breakers are almost universally employed, when any machine is used, having upright jaws, one of which is moved by means of a fly-wheel and eccentric.*

The discharge takes place only on the long side of the battery (generally on one side only) and in most cases through the screen. These are of sheet steel or Russia iron, about 0.4 millimeters thick, and punched with holes 8 millimeters long and about $\frac{2}{3}$ millimeters wide, of which there are about $7\frac{1}{2}$ to the square inch. The screens are so set as to bring on the inside the rim of the holes, turned up in punching.† They are set in openings cut in the housing, and made fast by means of close-fitting panes of iron or wood, and wedges. The height of the discharge-level above the die varies between 10 and 15 inches, and is ordinarily 11 to 12 inches.

For the purpose of amalgamating in the battery the free gold contained in the rock, amalgamated copper-plates (Fig. 1, t) are set under the charging and discharging openings, that is, immediately over the lower, iron part, of the battery-box, along its entire length. They are 8 inches and 4 inches wide (together, one foot) and incline about 45° to the horizon. Occasionally these copper plates are also introduced at the ends of the mortar. They either rest on the cast-iron mortar below, or (usually) upon iron pegs, fixed in the housings, and they are held at their ends in grooves. The plate of the rear wall is set in a wooden frame, and can be by means of a handle removed or introduced at will. The plates in front and at the sides, which are screwed fast, are only accessible after removal of the screen or the rear housings.

Immediately below the discharge-screen a wooden apron or table, (Fig. 1, t',) covered with copper, 10 to 12 feet long, and 5 or 6 inches wider than the distance between the battery-posts, is attached to the housings.

---

* Mr. Reichenecker's description of the stone-breaker is omitted, the machine being thoroughly explained in my last report, page 648. Mr. R. says one thing, namely, that the jaws are lined with corrugated plates of *steel*, which I think must be a mistake. The use of chilled cast-iron for this purpose is almost universal; and where it is departed from (as in Dodge's crusher) soft wrought iron, without corrugation, is substituted.—R. W. R.

† These screens differ from those of other localities, which are punched with circular holes and named after the sizes of needles.—R. W. R.

It is inclined 7 to 10 degrees below the horizon; its area is to that of the interior copper-plates about as 12:1. To make a tight joint, it is let into the sill (Fig 1, *i*) of the housing, and pressed against the latter by means of braces underneath. The sheet copper is fastened on with iron wood-screws. At the angles between the raised rim and the bottom of the table, the copper is either turned up for 1½ or 2 inches, or allowed to abut upon the rim, the crack being covered with a lath.

The wooden housings, screen-frames, outer plates, apron, &c., are all caulked with strips of blanket in the cracks and joints.

THE OPERATION OF THE MILL.

The quartz is brought from the mine, unless the mill is in or near the shaft-house, in wagons, generally with two mules each, and unloaded upon the charging-floor, where the necessary spalling is performed, as close as possible to the stamps, either by machinery, or, generally, by hand. Each wagon contains 32 cubic feet, or 35 hundred weight of rock.*

The principal object of the crushing is the simultaneous amalgamation of the free gold in the ore, and hence the ruling idea in the management of the process is to extract directly, and during the crushing, as high a percentage as possible; and but subordinate attention is given to any further treatment of the pulp.

Since the gold is in general finely disseminated, a fine crushing is usual. The number of drops per minute varies between 15 and 45, being generally 22 to 28.†

Feeding is always done by hand, and to all the stamps.‡ The battery-

* The practice of hauling rock to mill by the wagon-load, and the absence of means or inclination to weigh it, has led to the measurement of ore in Colorado by cords instead of tons. This is theoretically, in one respect, the most accurate way; since the cost of mining depends on the bulk rather than the weight of the material extracted, and what we desire to know of any vein is its value per fathom, not per ton. But practically there is no ascertained relation between the amount of ore sent to mill and the space actually excavated under ground, since no account is kept of the quantity thrown away in sorting. Moreover, the measurement of ore by cords is fatal to exact business transactions and to proper control by assays, &c., of the milling processes. "Four wagons make a cord," is no basis for a scientific metallurgical practice. The cord, as might be expected, varies according to the character and size of the pieces, and the closeness with which they are packed in the box or wagon. Mr. Hague gives for a cord of quartz, without heavy minerals, stamping size, loose, 6¼ tons; for the same, more closely packed, 7 tons, while pure iron pyrites, closely packed, would weigh nearly twice as much. A cord of ordinary ore may weigh 7, 8, or 9 tons, the average of 7¼ tons being not far from the truth. Mr. Reichenecker puts it at 7, unless his "hundred-weight" are meant for German ones, in which case he very closely agrees with Mr. Hague.—R. W. R.

† It is now beginning to be admitted in Colorado that a greater speed of stamps would be more economical of power. The important items of wages, interest, insurance, &c., are no greater for a rapid rate than for a slow one, while the actual effect per horse-power, and hence per unit of fuel consumed, is increased. See my last report, *passim*, and the chapter in this report on the speed of stamps.—R. W. R.

‡ The self-feeding batteries are not generally approved by American mill men, who claim that a faithful and discreet feeder can increase the product of the stamps by far more than the value of his wages; besides, he need not be confined to that work, unless he attends to several batteries. Very small mills, of three or four stamps, might, I should think, be advantageously self-feeding. An amusing instance is a small three-stamp mill belonging to a tenant on the southeastern part of the Mariposa estate, in California. It is run by water-power, and is self-feeding. The proprietor works elsewhere for wages, and the mill, being supplied with ore in the morning, feeds itself and crushes and amalgamates all day (rather rudely, it must be confessed) without any attendance whatever. Under these circumstances a profit is obtained from rock which would otherwise scarcely pay expenses.—R. W. R.

box is kept full for about 6 inches above the dies. The feeding is done in 12-hour shifts. A laborer can feed in one shift, allowing for $1\frac{1}{4}$ to $1\frac{1}{2}$ hours' average enforced idleness of the mill, about 95 cubic feet or 100 to 110 hundred-weight of hard rock, which he also spalls to first-size before charging. The same man can furthermore supply the quicksilver from time to time and regulate the flow of the battery-water. If the quartz is very hard, an assistant for alternate shifts, or a crushing-machine run by the feeder, is required.

The battery-water is supplied for rich rock in sufficient quantity only to prevent the pulp from catching on the aprons, say about 28 cubic feet of water per cubic foot of rock crushed. For rock poor in gold, (or poor in ore, which is generally the same thing,) the supply of water is increased, to increase the rate of working, so that the quantity amounts to 33 cubic feet and upwards to one cubic foot of rock crushed. The foregoing proportions of 28 and 33 cubic feet to one represent weights of the cubic foot of rock crushed, of about 125 and 108 pounds respectively. Per stamp per minute, the volume of the battery-water averages $\frac{1}{4}$ cubic foot. It has in summer its natural temperature; in winter it is warmed only enough to prevent congelation upon the apron, &c.

Amalgamation.—For the purpose of amalgamating the gold quicksilver is introduced through the charging-slit from time to time, generally once in two hours, and in quantities dependent upon the richness of the ore. Care is taken to distribute it as evenly as possible under the stamps. The quantity of the quicksilver employed is, on the average, three times as much as is afterwards recovered in the amalgam.*

The process of amalgamation is as follows: The quicksilver is finely divided by the stamps, and thus acquires the opportunity to coat or amalgamate the fine particles of gold. This fine division of the mercury is proved by the fact that two-thirds of the quantity charged generally escapes in the battery-slimes. The violent motion ("swash") of the battery-water, produced by the fall of the stamps, the particles of gold, amalgam or quicksilver are carried with the pulp upon the copper plates, to which they have an opportunity to adhere.

Very frequent addition of small quantities of quicksilver gives no better result than charging the same aggregate once in two hours. It seems to follow that the quicksilver is but slowly expelled from the battery little by little, after it has caught a quantity of gold about equal to that in the quicksilver which is retained by the inner plates. That which escapes through the screens is thinly fluid, and contains but a small percentage of gold, while the amalgam of the plates is either a pasty mass or a hard layer. Now, since the quicksilver which arrives on the plates is, as has been shown, nearly equal in gold contents with that which escapes, it follows that nearly the whole gold contents of the amalgam of the plates are the result of the enrichment, by floating particles of gold in the pulp, of the quicksilver adhering to the plates.† The same purpose is served by the outer as by the inner copper plates, as the pulp flows over them.

---

* This loss seems very large, but the fact of its existence is indisputable. Mr. Hague speaks of $\frac{1}{20}$ to $\frac{1}{10}$ of a pound of quicksilver per ton of rock, which is about the same thing. Even at present high prices of quicksilver, however, the value of the loss is not very great, only gold always escapes when mercury does.—R. W. R.

† This passage is obscure. Mr. Reichenecker's meaning appears to be, that the quicksilver in the battery takes up a small percentage of gold, and, while still fluid, is thrown by the swash, some upon the interior plates, some through the screen. That which catches on the plates gathers more and more gold, and grows stiffer and harder in consistency. Finally, the same process takes place with the amalgam caught on the outer plates of the apron.—R. W. R.

The movement of the pulp in the battery consists in alternate rising above and falling below the inner plates, combined with wave motions longitudinally along the battery-box. Outside, the pulp streams with uniform velocity over the inclined table, a movement which does not, like that within the battery, present moments of rest, favorable to the deposition of the gold. The only place where this is at all the case on the outer plates is the upper end of the apron, upon which the discharge falls from a height of several inches.*

According to foreging data these outer plates have an inclination of 7 to 10 degrees and a width of 10 to 12 inches per stamp, upon which about one-fourth of a cubic foot of pulp is discharged per minute. The discharge moves over them in a very thin layer, which moves (as in the case of shaking-tables, buddles, &c.) much more swiftly on the surface than on the bottom. Such particles of the gold and amalgam as sink with the larger and heavier pieces of ore to the bottom slide or roll slowly along, and have opportunity to adhere; but smaller particles are swept along by the more rapid surface-current of the watery sheet of pulp, without being able to reach the bottom. To this latter class belongs the greater part of the gold, especially of that which escapes through the seives, and almost all the particles of quicksilver and amalgam. Moreover, the absolute quantity of gold which can come in contact with the outer plates is less than that which may touch the inner plates, by the amount retained upon the latter. For all these reasons, the inner plates must furnish the greatest part of the gold obtained in the mill.

The coarser the particles of gold, the longer will they, after being rendered, by their separation from the ore or gangue, accessible to quicksilver, remain in the mortar-bed, where most of the latter is collected, and the better will be their opportunity of contact with it, by which means their subsequent adhesion to the plates is greatly facilitated. Moreover, the coarse gold will, either not at all, or very seldom, be lifted up to the discharge-level, until they have been pounded by the stamps into a more favorable shape, or crushed altogether, or changed in volume or specific gravity by a partial amalgamation. Hence they will remain in the battery at all events longer than the fine particles, and will be more likely to remain on the inner plates; and only a small portion will, after pulverization or amalgamation, reach the outer plates; while the fine gold, on the other hand, is lifted from the bottom immediately after being set free from the ore, and is held in suspension, together with the particles of amalgam, by the battery-water, until it is caught on one of the plates, or is discharged through the sieve.

While the substances are thus floating about, it is very difficult, on account of the thinness of the pulp, to unite the particles of gold and quicksilver; and this explains the fact already mentioned, that the quicksilver which escapes through the screens contains little gold. Moreover, of the gold escaping in the pulp only a small amount is in the two-thirds of the quicksilver originally charged, which likewise passes the screens. On the other hand, the gold escaping must be free gold in the pulp, almost wholly; and a part of it may be still inclosed in the quartz.

---

*This arrangement of the outer plates is a defect, which could easily be remedied by giving them, as is frequently done, several drops or stairs, instead of a smooth, uniform inclination.—R. W. R.

† Specific gravity, modified by the resistance of the medium, determines the precipitation of different bodies suspended in water. But the resistance is proportioned by the surface, and small bodies have more surface in proportion than large ones, hence they do not sink as easily.—R. W. R.

Treatment of the plates and mortar;—removal of the amalgam.—Several times daily the crushing is suspended, the screens are removed, and foreign substances, principally splinters of wood, which may be floating about in the mortar, are taken out; after which the screens are replaced, the outer plates are rinsed with water, and cleansed from grease and oxide by means of cyanide of potassium, alone or with ammonia, poured on and rubbed with a soft brush or woolen cloth. A film of grease, of hydrated copper oxide or copper salts, (carbonate, sebate, cyanide, &c.,) hinders the combination of the quicksilver with the plates and with the gold. Grease finds its way into the battery partly in the battery-water, and in the ore,* partly from the lubricating material employed on the cams and journal-bearings. As for oxidation, the copper contained in the film of amalgam coating the plates oxidizes when, for lack of being completely covered by the flowing battery-water, it is exposed to the air.

Accumulation of pulp† on the outer plates, resulting from occasional misproportion in the amount of battery-water, must be at once removed by rinsing.‡

Once a day the gold amalgam adhering to the outer plates is removed, after the latter have been rinsed, by scraping with a sharp-edged piece of India-rubber; and the plates are cleaned and sprinkled with a little fresh quicksilver, which is then spread over them by means of the brush or woolen cloth already described.

The inner plates are taken out generally twice a week, (but in many cases only once,) and the adhering amalgam is scraped off as far as possible without exposing the copper, a knife or chisel—not too sharp—being employed if necessary. Quicksilver is then sprinkled upon them and rubbed off again with the above-described piece of India-rubber.§ In this operation just so much additional amalgam is removed as leaves behind an even, thin layer, which is necessary for the adhesion of fresh gold. Finally the inner plates, immediately before they are replaced, are cleaned from grease and oxide, (a little more quicksilver being sprinkled and spread upon them,) and rinsed with water.

Generally once a week, when the inner plates are removed, the mortar and the stamps are examined for portions of amalgam which collect in thin depressions and joints, and which, when rich ores are under treatment, amount to considerable value. At the same time the rear housing is removed, the mortar emptied, worn-out shoes and dies are replaced with new ones, and other necessary repairs are made.

In summer the mills are usually stopped from Sunday morning to Monday morning; but in winter they are run during this period.

Further treatment of the amalgam obtained in the stamp-mill.—The amalgam obtained from the plates is diluted with a larger quantity of

---

* The use of stearine candles, almost universal in our American gold and silver mines, leaves much grease in the ore. Lamps would on this account be better.—R. W. R.

† This term, which I should perhaps have explained before, is applied to the crushed product escaping through the screens. In dry crushing the "pulp" is dust; in wet crushing, slime mechanically suspended in the battery-water.—R. W. R.

‡ For this purpose, it is well to keep a small rubber hose in readiness, connected with the water supply, so that a stream of water can be at any time directed upon the part of the apron which is thus encumbered.—R. W. R.

§ The object of this is to dilute as it were with mercury the hard amalgam which cannot be evenly scraped off by means of the knife. Gold-amalgam catches gold better than pure quicksilver or copper-amalgam; hence the care with which the complete removal of all amalgam from the copper plates is avoided. The gold-amalgam on the inner plates is generally harder (because richer) than that upon the tables.—R. W. R.

quicksilver, and worked together thoroughly with the hand into one mass, the adhering particles of pulp being separated and washed away. The impurities, consisting chiefly of copper and lead, which still float on the surface of the mercury, are removed by means of a wet woolen cloth, until the surface is perfectly bright. Finally the mass is pressed through strong, thick canvas-filters.* The amalgam remaining in these contains about 64 per cent. of quicksilver, which is removed by distillation in a cast-iron retort. In this way is generally obtained a porous argentiferous gold, more or less alloyed with quicksilver, copper, and sometimes even lead. This gold is a marketable commodity.

The particles of ore and the other skimmings removed from the amalgam are collected, and generally rubbed fine, and digested with nitric acid, after which the greater part may be treated like the original amalgam from the plates.

Conditions of a good result from the amalgamation.—These are:

1. Very fine stamping.

2. The copper plates must have a coating of gold amalgam. This is secured for new plates either by rubbing on gold amalgam, or by coating them with quicksilver only, (forming copper amalgam,) and then rubbing over them the gold amalgam which gradually collects upon them from the pulp. No amalgam is removed until a hard layer of it has formed on the plates.

3. Use of the proper quantity of water. When the supply is inadequate, the mortar fills up with pulp, the screens are choked and the plates are covered up. The gold and quicksilver have more opportunity to come in contact with one another, but no chance to reach the plates. Too much water, on the other hand, leads to coarser crushing, less complete mechanical exposure of the fine gold, less contact of gold and quicksilver, and a premature sweeping off of both. The addition of quicksilver in larger quantity does not practically overcome these evils, since, though it may cause the formation of more amalgam, the excessive current of the water will sweep it away from both the inner and the outer plates.

4. Proper temperature of the battery-water. A high temperature, indeed, favors the amalgamation; but the amalgam formed is more liquid in proportion to its contents of gold, and, instead of adhering to the inner plates at first contact, tends to run down upon them and fall back into the mortar. At the proper temperature, on the other hand, particles of amalgam adhere to the inner plates, gradually accumulating to dendritic aggregates and undulating radial forms, the mass of which possesses solid consistency and a rough surface. In this way the plate soon acquires a corrugated surface, which greatly facilitates the further accumulation of quicksilver and gold, whereas, at a high temperature, the surface remains more or less smooth. The richer the amalgam on the plates, the more likely is it—especially when the battery-box is accidentally over-filled—to be washed off by the pulp, pulverized by the stamps, and carried out through the screen. Too high a temperature causes similar evils upon the outside plates.

5. The addition of quicksilver in proper quantity. Too much quicksilver is attended by results similar to those of excessive temperature. Moreover, the increased quantity of quicksilver, the battery-water remaining the same, causes much more to be deposited on the outside plates. This may dissolve the thin coating upon them, and expose and

* For small quantities, a piece of dressed buck-skin, or chamois-leather, is employed, in which the amalgam is placed, and the superfluous quicksilver expressed by wringing.—R. W. R.

amalgamate, here and there, the copper beneath. The result is a decrease in the ability of the plates to catch and hold the gold, and an excess of copper in the amalgam obtained. Of course, on the other hand, the addition of too little quicksilver diminishes the amount of gold caught on the plates.

6. Proper height of the charge in the mortar. This should not be allowed to rise higher than about three inches below the lower edge of the inner plates. If the quartz and pulp in the battery come nearer the plates, there is too much and too coarse stuff thrown upon the latter, preventing the accumulation of amalgam, or displacing it after it has collected.

7. Regular feeding. Occasional overcharging of the battery has the same effect as too little battery-water, besides of course producing the evil just alluded to, of too close an approach of the crushed or half-crushed ore to the inner plates.

8. Care in keeping the plates clean.

Common accidents in crushing.—The usual accidents in stamp-mills (generally the result of defective management) are: the loosening of the various parts of the stamp, the breaking of the cam or the shank of the shoe, and the springing or bending of the stem.

All the parts of the stamp may work loose through its running "empty" or bare, in consequence of a lack of rock, or through the presence of pieces of broken dies or shoes beneath the stamps. The stem may be drawn out of the head if the battery-box is filled too high, in which case the adhesion between the stamp-head and the pulp may be greater than that between head and stem. The shank of the shoe may break off, if a piece of cast iron from a die or shoe gets under the shoe in the neighborhood of its edge. Displacement or fracture of cams, and curvature of the stem may be caused by running the cam-shaft backwards, in which case the concave under side of the cam is pressed upon the upper part of the collar or tappet. A cam may also be broken by the fall of a stamp which has been hung up and is carelessly let go, so that the tappet strikes the cam with a blow. Neglect of proper lubrication (for which tar is generally employed) leads, here and there, to the premature wearing-out of a cam.

Workmen and their duties.—The immediate superintendent of the whole mill is usually the so-called foreman, who very rarely possesses theoretical knowledge, but who has himself discharged, at various periods, the duties of every position in such works, and is thoroughly familiar with them all, so that he can at any time take the place of an absent workman, or fully instruct a new hand. The foreman is responsible for the general regularity of operations, and particularly for those more immediately connected with the collection of amalgam, its safe keeping, and the final correct delivery of products to the owner. These processes (the clean-up, retorting, &c.) he performs as far as possible alone. (Sometimes the owner prefers to retort his own amalgam.) Complete trust is therefore necessarily reposed in him; and, since he is responsible for the proper conduct of every part of the operations, he usually has the power of engaging and discharging workmen. At least the owner makes no changes in the force contrary to the foreman's wishes. In stamp-mills, however, which are driven by steam-power, the care of the engines and gearing is usually more or less completely taken from his control, and intrusted to the two engineers. In small mills, up to say fifteen stamps, the foreman is commonly at the same time the first engineer, and the two feeders must, when he is prevented by absence or otherwise, tend the engine in addition to their other duties. In very

large mills, on the other hand, having more than fifty stamps, a special engineer with one or two assistants is required; and to these is given the care of all the machinery, the foreman being sufficiently occupied with the supervision and partly personal execution of the operations immediately connected with stamping, amalgamation, &c.

The necessity of supplies is reported by the engineer or foreman to the owner or his agent, that the required purchases may be made in time.

The foreman, like all the workmen, not excepting the engineers, is very rarely engaged for a specified period, but may at any time, without previous notice, resign or be discharged.

Wages are paid weekly or fortnightly. The pay of an ordinary workman, such as the feeder, per diem, is about $2 40; of the second engineer, $2 60 to $3; of the foreman or first engineer, from $3 20 to $4.

If a stamp-mill has a single foreman, he is usually at his post from 7 to 12 in the forenoon and from 1 to 6 in the afternoon, the owner or agent relieving him in the interval. In large mills, having two foremen, they change shifts, as do the engineers and other workmen, at the twelfth hour.

There has been hitherto no benevolent fund, of assessments or otherwise, for the relief of workmen injured or falling sick during service, or for the assistance of their families.

RESULTS.

Capacity of the stamps.—The normal average is about 1.09 cubic feet, or from 115 to 130 pounds of rock hourly, per horse-power developed by the stamp.

Wear.—The wear of the die is nearly half as great as that of the shoe, both together amounting to about 185 pounds on the average for 1,000 hundred-weight of rock crushed.

Product of gold.—The product of gold from the copper plates varies between 30 and 50 per cent. of that in the ore, and averages about 40 per cent. A smaller yield than this is usually due to imperfect disintegration (too coarse crushing) of the ore; a larger yield, chiefly on the inner plates, to the presence of more coarse gold.

About 15 per cent. of the gold remains on the average, under normal conditions of running, enveloped in the unredeemed portions of the ore, (*i.e.*, the larger particles;) hence, about 45 per cent. gold actually freed from this envelope still escapes the plates; and a small part only of this, say 7 per cent. out of the 45, is dissolved in the two-thirds of the quicksilver charged, which, as we have seen, likewise escapes from the plates. The remaining 38 per cent. escapes as unamalgamated gold.

Of the amalgam obtained the interior plates yield about 67 per cent., the outer 20 per cent., the skimmings 13 per cent.; or, distributing the latter in due proportion, the inner plates yield three-fourths, and the outer plates one-fourth of the amalgam obtained, or 30 and 10 per cent., respectively, of the gold contained in the ore. Reckoning by units of surface, the inner plates collect 36 times as much gold as the outer.

We will designate by M the total gold in the ore; A, the gold caught in the battery on the inner plates; B, the gold caught on outer plates, (A being about 3 B;) *g*, the coarse gold caught on the plates; *f*, the fine gold caught on the plates; C, the free gold* escaping from the plates; D, the gold escaping not freed from ore or rock; K, the coefficient or percentage of yield.

* Including, apparently, that which escapes as amalgam.—R. W. R.

Assuming that no coarse gold is lost from the plates, and that the proportion of fine gold caught to that which escapes free is constant and independent of g and D, we may calculate from the value of C or D the proportion between f and g.

From the equations

$$(1)\quad A+B+C+D=M, \text{ and } A+B=KM$$

we have

$$(2)\quad C+D=(1-K)\,M$$

Making g and $D=O$, we have $f=KM$, and $C=(1-K)\,M$ (*)
Hence,

$$(3)\quad \frac{C}{f}=\frac{1-K}{K}$$

a constant proportion; whence,

$$f=\frac{K}{1-K}\,C \text{ and } g=KM-f=KM-\frac{K}{1-K}\,C$$

and

$$(4)\quad \frac{f}{g}=\frac{C}{(1-K)\,M-C}=\frac{(1-K)\,M-D}{D}=\frac{C}{D}\ (\dagger)$$

If we now designate with F and G the quantities of fine and coarse gold in the ore, (the whole of the latter being saved, or $G=g$,) we have

$$\frac{F}{G}=\frac{f+(1-K)\,M}{g}$$

or,

$$(5)\quad \frac{F}{G}=\frac{\frac{(1-K)^2}{K}M+C}{(1-K)\,M-C}=\frac{\frac{1-K}{K}M-D}{D}$$

Assuming further that no coarse gold escapes from the battery, but that all the gold passing the discharge is fine, and designating with f' and g' the fine and coarse gold caught on the inner plates, and by C' the total free gold carried through the discharge, and by F' and G' the amounts (on this assumption) of fine and coarse gold in the ore; we may obtain the proportions $\frac{f'}{g'}$ and $\frac{F'}{G'}$ from equations (4) and (5) by substituting for K the value 0.75 K, and for C the value $C'=B+C=0.25\,KM+C$.‡ This gives us:

$$(6)\quad \frac{f'}{g'}=\frac{0.25\,KM+C}{(1-K)\,M-C}=\frac{(1-0.75\,K)\,M-D}{D}=\frac{B+C}{D}$$

$$(7)\quad \frac{F'}{G'}=\frac{\frac{(1-0.75)\,K^2}{0.75}M+0.25\,KM+C}{(1-K)\,M-C}=\frac{\frac{1-0.75\,K}{0.75\,K}M-D}{D}$$

* Since f and C are independent of g and D, we may put the latter $=0$ without affecting the proportion between the former. In other words, by the original proposition, there being no coarse gold lost, and the gold lost by reason of envelopment in quartz, etc., not affecting the amalgamation, it may be assumed, in considering the proportions of the fine gold caught to the fine gold lost, that there is no coarse gold and that the crushing is perfect. The proportion $\frac{C}{f}=\frac{1-K}{K}$ is true on this hypothesis for all values of g and D.—R. W. R.

† From which it seems, that though the proportion between f and C is independent of the *values* of g and D, it is not independent of the *proportion* $\frac{D}{g}$.—R. W. R.

‡ Mr. Reichenecker's calculation is so condensed that a little explanation may not be unacceptable. Since A is 3 B, or the gold saved on the inner plates is three-fourths of

For $K = 0.4$, (40 per cent.,) and $D = 0.15$ M, we have from equation (3) $\frac{C}{f} = 1.5$; from equation (4) $\frac{f}{g} = 3$; from equation (5) $\frac{F}{G} = 9$; from equation (6) $\frac{f'}{g'} = 3.67$; and from equation (7) $\frac{F'}{G'} = 14.6$. (*)

The loss in melting the retort metal is generally about 8 per cent.,† due mostly to the quicksilver retained in it. The regulus contains a varying amount of silver, seldom less than 15 per cent., and very little, say 1 per cent., of copper.

Cost of the gold extraction.—The cost of working, *i. e.*, crushing and simultaneous amalgamation, is, for 1,000 hundred-weight, about as follows:

Wages	$39 60
Wear of shoes and dies	23 15
Steam-engine	85 70
Interest on capital	32 60
Loss of quicksilver	2 35
Sundries	3 85
Total	187 25

This is, therefore, the minimum paying yield for a steam stamp-mill, aside from the cost of mining and transportation. These items amount for 1,000 hundred-weight seldom to less‡ than $300, (freight being, on an average, about one-sixth of the running cost.) To obtain, therefore, the minimum yield which will cover all mining freight and reduction expenses, we must include this item, and increase the estimated loss of

the total saved, K, or the percentage of yield for all the plates, becomes 0.75 K when the inner plates only are considered. And C, the amount of free gold escaping from all the plates, becomes, when the inner plates alone are considered, $B + C$, or the whole amount passing the screens. But $A + B = K M$; and $A = 3 B$; hence $B = 0.25$ K M, and $C' = 0.25$ K M $+ C$. It will be seen that to determine the proportion of fine and coarse gold saved in the battery, the outer plates are assumed to be wanting, and the whole discharge is treated as a loss.—R. W. R.

* These results may be thus expressed in words. If of the gold in the ore 40 per cent. is saved, 30 in the battery and 10 on the outer plates, 15 per cent. is lost, enveloped in quartz, and 45 per cent. escapes as free gold, then, assuming that no coarse gold is lost, and that the proportion of fine gold saved is independent of the amount of coarse gold saved and of the amount lost through insufficient crushing, it follows:

1. That two-fifths of the free fine gold is saved and three-fifths lost.
2. That of the gold saved three-fourths is fine gold.
3. That of the gold in the ore nine-tenths is fine gold. If we assume that no coarse gold passes through the screens, then,
4. Of the gold saved in the battery-box $\frac{367}{467}$, or 78 per cent., is fine.
5. Of the gold in the ore $\frac{143}{156}$, or 93 per cent., is fine.

It will be seen that these results turn on a definition of coarse and fine gold. These terms are relative and vague. As the problem is here stated, however, in 1, 2, and 3, all gold fine enough to escape from the plates, and in 4 and 5 all gold fine enough to escape through the screens, is called distinctively fine gold.—R. W. R.

† The average of 26 meltings, given by Mr. Hague, (U. S. Geol. Expl. Exped., vol. iii, p. 554,) is 5.42 per cent.—R. W. R.

‡ And frequently, it might be added, to a great deal more. Six dollars per ton for mining and hauling is below the average.—R. W. R.

quicksilver in proportion, (*i. e.*, from $2 35 on $187 25 to $6 60 on $491 50,) giving the following estimate for 1,000 hundred-weight:

Cost of quartz at mill		$300 00
Crushing and amalgamation	$184 90	
	6 60	
		191 50
Total		491 50

This yield represents $9 83 per ton, or an actual amount in the ore of $14 74 per ton, or $103 18 per cord. These estimates are based on the supposition that the tailings are run off without further attempt to save the quicksilver or gold which they contain.* When water is the motor, the minimum paying yield (possible profit from further concentration not being reckoned) is $406 30 per 1,000 hundred-weight, or $8 13 per ton. In this case the milling cost proper is $101 60, or $2 03 per ton, and is to the mining and hauling cost about as 1 to 3.

II. FURTHER CONCENTRATION AFTER CRUSHING.

The further concentration has for its chief object the saving of as large a portion as possible of the gold which has escaped from the plates. In the case of ores which contain considerable amounts of silver as well as gold, the saving of the argentiferous portions is desired at the same time. Both objects are sought by the separation of the cleaner portion of the battery slimes into two sorts, each containing gold ore, (enveloped gold,) free gold, auriferous quicksilver, and silver ore, the specific gravity of the two classes being, for the heavier, say, 3.6 to 4.6, and for the lighter, 3.0 to 3.5. The first class is subsequently subjected to further pulverization and amalgamation, and both classes are then concentrated until

*Subtracting from the total of $491 50 the cost of mining and freight, we have $191 50, or $3 83 per ton. The interest on capital being also subtracted, we have $158 90, or $3 18. The average of 1,300 tons at the Ophir Company's mill (see Mr. Hague's report, already quoted, p. 555) was $3 69. Mr. Hague's own estimates compare with those in the text as follows:

	Hague, per ton.		*Reichenecker, per ton.*
Labor	$1 25	Labor	$0 79
Fuel	1 00	Fuel and engineers	1 72
Castings and ordinary repairs	35	Castings and ordinary repairs	46
Quicksilver	5	Quicksilver	13
Water, when purchased	20	Sundries	8
	2 85		3 18

Mr. Hague adds: "Making due allowance for other supplies not enumerated, extraordinary repairs and miscellaneous expenses, the estimated cost will accord closely with the figures just given as the result of the experience of the Ophir and the Sensenderfer mills. Of course the above items will vary considerably in different mills. The cost of fuel depends not only on the price paid for it, but on the economy with which it is used, the kind of boiler employed, and the proper adaptation of all the machinery to its purpose. The same remark applies to the economy of labor, while in all mills an essential condition of cheap work is constant employment at full capacity."

Mr. Hague takes no account of interest on capital; and I think it is difficult to include this item in estimates of running cost, though it certainly constitutes a large tem of expense, and is disastrously important when the mills are run too slowly, or on less than full capacity. Mr. Reichenecker reckons it very high; $32 60 on 50 tons of ore represents about 2 per cent. a month on the capital necessary to build a ten-stamp mill, crushing ten tons daily. I do not know, however, precisely on what basis his calculation is made.—R. W. R.

the product can be used in the matte-smelting process.* The volume of the two classes together is at least 10 per cent. of the rock sent to mill.

The first separation of the slimes either takes place upon round buddles, or the first-class is collected in blanket-sluices and the second in a box. The further treatment of the first-class is effected in pans, and the final concentration upon hand-buddles.

APPARATUS OF THE FIRST SEPARATION.

The round buddle, (Fig. 3.)—This is a conical buddle, about 19 feet in exterior, 3 feet in interior diameter, and ⅝ inch inclination per radial foot. The central block A, about 2¼ feet high and 23½ inches across the top, bears the journal-block *a* for the foot of the shaft B. About 1 inch above *a* is a wide conical collar, C, on the shaft, 1 inch high, 22 inches in diameter, and placed with the flat side downward. Above this are four attachments, *c* for the brush-arms D; and, cast solid with these, a disk, *d*, about 8 inches in diameter, serving as bottom to the wooden vessel E, about 7 inches high.

The slimes fall through the bottom of the conductor F into E, over the edge of E, upon the sloping surface of C, and flow from this across the slightly projecting edge of the block A upon the hearth or buddle H. At two points in the rim-wall G are gates, *e*, in which are bored small apertures, *m*, about 1½ inches in diameter. Through these the stream with the lighter (earthy) matter escapes.

The shaft carrying the brushes makes 6 to 7 revolutions a minute. The supply of slimes is 4 to 5 cubic feet per minute, containing about 3.1 pounds of crushed material per cubic foot of water. To fill the buddle to the mean height of about 2½ inches takes three days. The contents are separated into two classes by a circle drawn about 3¼ feet from the central block. The (dry) weight of the concentrates thus obtained is about 2.5 and 10.4 per cent., or in all, 12.9 per cent. of the weight of the rock crushed; and their specific gravity is respectively 4.35 and 3.4, or 3.55 for the whole.

Since no regular attention is required, except when the concentrates are to be removed, one workman can attend to three buddles. In small concentrating works the workman has other duties, such as the spalling of the rock for the stamps. The cost of labor at the buddle may be reckoned at two shift-wages per 1,000 hundred-weight.

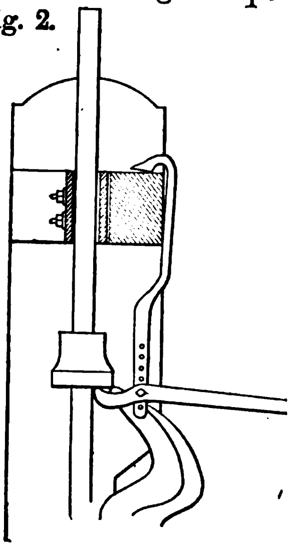
The blanket-sluices.—These are set below the outer plates or aprons of the battery. They are about 12 feet long, 1½ to 2 feet wide, and inclined full 2 inches per foot, or about 10°. Upon each are laid two blankets, which are washed at intervals of one and a half to two hours. The quantity of slime passing per foot of sluice width is about 0.7 cubic feet per minute, containing, as above remarked, about 3.1 pounds of solid matter per cubic foot of water. The blanket-concentrates amount to about 2.5 per cent. of the original crushed ore, and have a specific gravity of perhaps 3.4. The blankets are washed by the feeder or spaller, or in small mills by the foreman.

The box or launder has various dimensions. In width it may be anywhere from 0.6 to 1¼ feet per cubic foot of slimes supplied per minute, and in length from 4 to 12 feet. The depth is 1½ to 2½ feet. A launder 0.6 feet wide per cubic foot of slimes, 10 feet long, and 1½ feet deep,

* As flux for the richer ores, in reverberatories. The process is practiced in Professor Hill's works at Black Hawk.—R. W. R.

Lever for raising stamps.

Fig. 2.



The quicksilver is added in the pan, as the concentrates already con-

Hill's works at Black Hawk.—[illegible]

saves on the average about 12 per cent. of the weight of ore crushed, with a specific gravity of 3 to 3.2. This may be looked upon as a minimum yield for the launder. Partitions are rarely used. Two, sometimes three boxes are placed side by side, and used alternately. All the boxes of a mill have, however, the same dimensions, so that only one class of concentrate is obtained. The cleaning out of the boxes is performed sometimes by the spaller or the blanket-washer, sometimes by the workman who attends to the subsequent processes of separation.

APPARATUS FOR PULVERIZING AND AMALGAMATING THE FIRST CLASS OF CONCENTRATES.

The blanket-washings and the corresponding concentrates from the inner circle of the buddle are ground in iron pans with stone drags, and subsequently treated in dolly-tubs to extract the auriferous quicksilver.

The pan.—This consists (Figs. 4 and 5) of a cast-iron vessel, A, 8½ inches high in the clear, generally 36 inches in diameter at the bottom, and 43 at the top; the thickness of sides and bottom is about ¾ inch. It has an interior cone, *a*, through which passes the wrought-iron shaft B, 1½ to 1¾ inches thick. The cone has an exterior diameter of 12 inches at the bottom, and 6 inches at the top. The channel for the drag-stones, C is therefore 12 inches wide at the bottom. The shaft rests upon the cone by means of a ring, *e*, cast or screwed on, and fitting in a recessed seat in *a*. Revolution is communicated from below through bevel-gearing *b b'*. At the distance of 18 inches above the bottom of the pan, the shaft carries two arms, D D', 13 to 14 inches long, and provided at the ends with hooks, *c'*. To these are attached chains, *d d'*, about 16 inches long, which connect with hooks *c'* on the front end of the drags. The latter are 5 to 6 inches high, weigh 70 to 90 pounds each, and are generally of fine-grained granite.

The pan is generally fastened with screw-bolts through four flanges, *f*, cast on in the plane of the bottom to a wooden bed, *g*, about 3 inches thick, which serves at the same time as a guide to the shaft. This bed rests in turn on four cast-iron legs, *h*, connected two and two by cast-iron cross-pieces, *p*, which serve as supports for the horizontal driving-shaft *q*. The latter is provided for each pan with a coupling, so that it can be put in or out of gear at will. Immediately below the bed *g* the two legs of each pair are bolted by means of cast flanges to a wooden cross-piece, *i*. The feet are bolted to longitudinal sills *k k'*.

For the purpose of discharging the pan, an opening, *m*, about ¾ inches wide, is provided in the bottom, on the front and near the side. This can be closed by a screw plug with a handle, *n*. Beneath the opening is a wooden gutter, *o*, which leads to the dolly-tub.

The pan is charged with 70 to 90 pounds of the blanket or buddle concentrate, and water is added until the mass will just cling to a stick dipped in it without dropping off. This fills the pan for about 1½ inches. The charge remains about eleven hours under the action of the drags. which travel at the rate of ten to eleven revolutions per minute. By this treatment the particles of quartz are ground finer, and gold is exposed to the action of the quicksilver in the pulp, while, on the other hand, particles of gold already set free by the stamps, but not yet amalgamated, have a prolonged opportunity of uniting with the mercury. A little before the end of the process the charge is further diluted with water; and finally the whole is drawn off through the opening in the bottom and conducted to the dolly-tub.

No quicksilver is added in the pan, as the concentrates already con-

tain a sufficient quantity, lost from the battery-plates and aprons. The usual practice is to provide one pan of the dimensions here given for every six or seven stamps.

The dolly-tub.—This is a cylindrical wooden tub, *a*, (Figs. 6, 7, and 8,) having (when one dolly-tub is calculated for three pans) 2½ feet interior diameter, and 14 inches clear height. Up to about 11 inches from the bottom it is reënforced with a 1¾-inch wooden lining, *b*, so that the clear diameter is here about 2 feet. The sides and bottom of this interior are covered with amalgamated sheet-copper, like the plates of the stamp-mill, which rises in the center to a cone, *c*, about 9 inches in diameter at the bottom, 5 inches at the top, and reaching to within about 1½ inches of the upper edge of the tub. The copper lining is set in segments, the ends of which, *r*, where they come together, are bent up into ridges about 1 inch high. Upon these the pulp strikes when stirred, and the deposition of gold and quicksilver is thus facilitated.

Two bung-holes, *d*, *d′*, are placed respectively 3 and 6 inches below the upper edge, and a third, d^2, in the bottom. Below the lower side hole, *d″*, is attached an apron, *e*, about a foot wide, and covered on the bottom with copper.

The dolly-tub rests on several timbers, *f*, about 6 inches high. Two vertical posts, *g*, *g′*, set in the floor on either side, and united above by cross-pieces, *hh′*, carry the spindle *i*, with the stirrer *k*, and the pulley-shaft *n*.

The wooden stirrer consists of the carrier *k*, with two arms, *l*, *l′*, at each end, of which the outer *l* runs vertical, while the inner *l′* has nearly the inclination of the side of the cone *c*. By means of the ring with clamp-screw *m*, the stirrer may be made fast at any point on the shaft. The shaft is composed of two parts, with a coupling, *ss′*, by means of which the movement of the lower part, with the stirrer, can be stopped independently of the gearing above. The power is generally obtained from the horizontal driving shaft *q*, (Figs. 4 and 5,) of the pans, by means of the belt-pulley *t*, the pulley-shaft *n*, and the bevel-gearing *oo′*. The upper half of the spindle is thus set in motion, being supported by the upper cross-piece *h*, by means of the ring and clamp-screw *u*. The lower coupling is held by the lever *v*. The cross-pieces *hh′*, both act as guides.

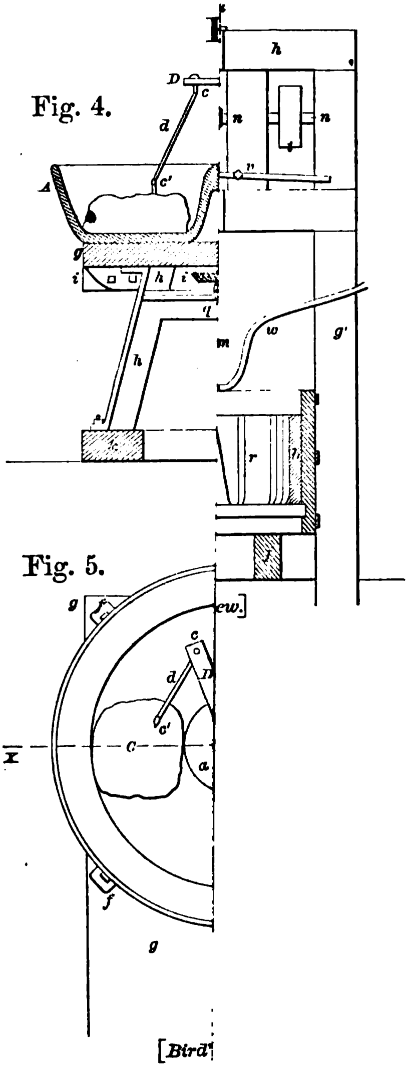
The dolly-tub is filled by means of the gutter *o*, (Figs. 4 and 5,) with the contents of a certain number of pans. If it gets too nearly full before all the pans are discharged, a portion of the water is drawn off, after settling, from the bung at *d′*. Hereupon the stirrer is set in motion, by putting the coupling in gear, with eighteen to twenty revolutions per minute, and the upper bung-hole *d*, is opened, while a continuous stream of fresh water is turned through a hose or pipe, *w*, into the tub. Through the constantly open upper hole *d*, a quantity of water escapes, equal to the quantity of fresh water entering, and carries with it gradually the floating slimes out over the copper-plated apron *e*, upon which it is expected that the gold or quicksilver will be caught. The slimes from this apron flow into a box.

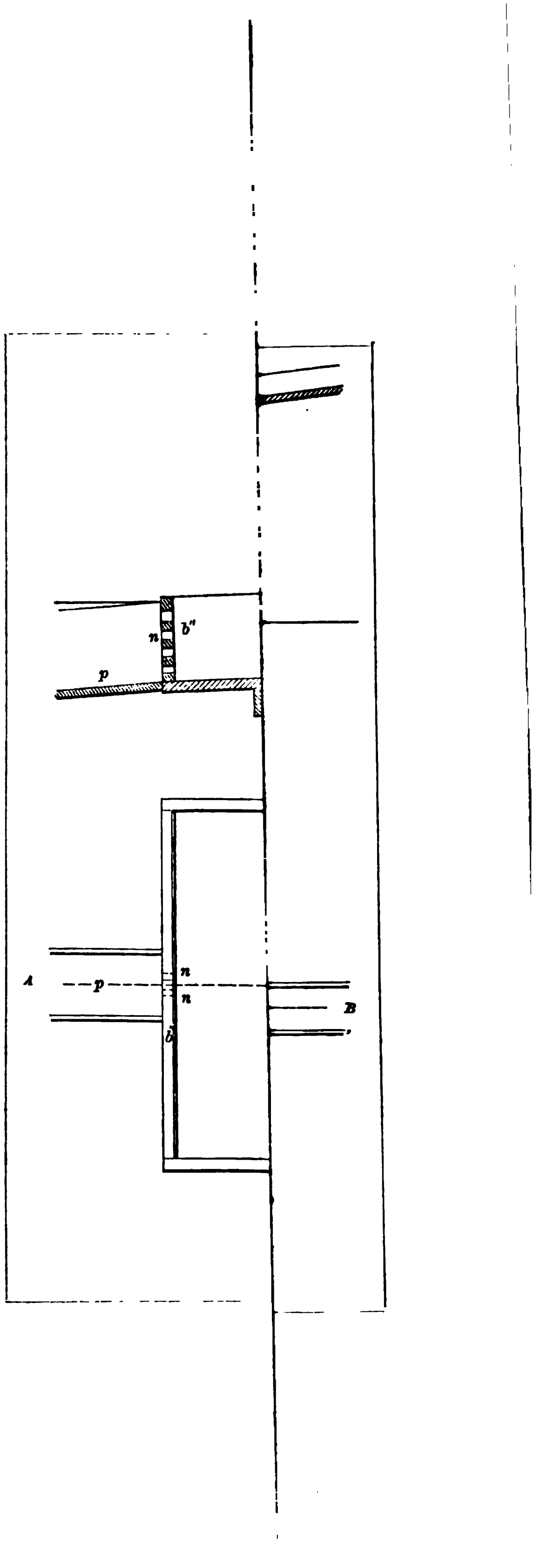
After about eleven hours of stirring the tub is gradually discharged, by opening the hole in the bottom, the more solid portions of the charge being received in a dish held below. The dolly-tub is then filled anew.

Once or twice a week the amalgam which clings to the copper lining is removed, and treated in the same manner as that from the plates of the stamp-battery. The solid portion of the charge, received in a dish, as above mentioned, is treated like the "skimmings" of the battery

Fig. 4.

Fig. 5.





b''
n
p
A
p
n
n
B
b

The attendance upon the dolly-tub and pans is performed by the foreman, with the help of the blanket-washer or the buddle-tender.*

APPARATUS FOR MORE COMPLETE CONCENTRATION.

For this purpose, buddles are almost universally employed. *The inclined buddles* (Figs. 9 and 10) are 4½ to 5½ feet wide, 10 to 14 feet long, and 1¼ to 1½ feet deep. The inclination of the floor is about ⅜ inch to the foot. They are so constructed as to be easily transported from one mill to another. The floor *a* and walls *b* are of two-inch plank, strongly nailed together, the floor-plank lying longitudinally, and being held together with scantling cross-pieces, *c*. The upper end wall *b′* is inclined 20° to 30° from the vertical. The feeding and distributing floor is in three parts; the lower one, *e*, 6 to 8 inches long, and as wide as the buddle, rests on the upper end *b*, and prolonged side walls *b*. The middle part *e′* is 15 to 16 inches long, at the lower end likewise as wide as the buddle, and contracts to about one-third of this width at the upper end. Upon it are fastened radial cleats, *g*, about 1½ inches high, ½ inch wide at the upper end, and 1½ to 1¾ inches at the lower, so disposed that the spaces between them are about 1 to 1¼ inches at the upper end, and 3 to 6 inches below. This portion rests with its lower edge on the upper edge of the part *e* below it, and is supported above by the plank prop *h*. The uppermost part *e″* of the table is 14 to 17 inches long, and contracts in width on this length not quite one-half. It is sometimes provided with one or two rows of rhomboidal wooden blocks, *i*, 1 inch in height and the same in width, and 4 to 5 inches in length. Each is fastened with a single tack, and can be turned at will to any desired angle. The uppermost block *i*, by which the slime current is divided into two streams, is placed in the middle on the lower end of the mixing trough *f*. Frequently, however, guide-blocks, *i*, are wanting, with a single exception. This is then placed in the middle of the lower end of *e″*, and not in the mixing trough. This portion of the table rests on the upper edge of the next below, and on a prop, *h′*. All these parts have a rim wall, *d*, 4 to 6 inches high. Their inclination is 11° to 12°.

The mixing trough f, for diluting the slimes, is a wooden box about 4 feet long, at the lower end as wide as the table with which it connects, and at the upper end about twice as wide. The side walls are at the lower end about 6 inches, at the upper end 12 inches high, as is also the end wall. The trough rests below on the upper edge of the distributing table *e″*, and above on a prop, *h″*. Its inclination is the same as the foregoing. Occasionally it is furnished with two cleats, *k*, intended to hold a sieve. In the end wall of the trough is a notch, in which fits the supply trough *m* for the buddle-water.

In the lower end wall *b″* of the buddle are two rows of holes, *n*, for the escape of the water and tailings. These can be closed with wooden plugs.

The buddle sometimes stands free over a ditch; sometimes it is imbedded upon old tailings. In the latter case a tail-race, *p*, is connected with it, generally a sluice-box or ditch in the ground.

To attend the buddle two workmen are required, one of whom shovels the pulp into the mixing trough and regulates the supply of water, while the other stands on a thwart, *q*, 3 or 4 feet from the upper end of

* There is no danger of losing gold by theft during the extraction processes, except from those machines which accumulate amalgam. Hence, the foreman, who is responsible for the gold produced, takes care to be personally watchful of plates, pans, and dolly-tub.—R. W. R.

the buddle, toward which his face is turned, and continually moves a brush obliquely over the buddle-charge. The brush is about 1¼ foot long, and is set with horse-hairs 9 to 10 inches long, in bunches ⅜-inch thick. The handle is about 6 feet long and obliquely set in.

When the buddle has filled to a depth of 9 to 12 inches, (which takes three to four hours,) the charge upon it is divided into three parts. The first comprises all above a line drawn across the buddle 2 or 3 feet from the top; the second, all between this and another line drawn across 2 or 3 feet below; and the third, all below the latter line. The first contains still about 10 per cent. of gangue, and has a specific gravity of 4.4 to 4.6; it is considered as sufficiently concentrated, and is salable. The specific gravity of the second portion is 4 to 4.3; it is saved to be buddled again. The third has less specific gravity than the original slime put on the buddle; it is thrown away.

As a general thing the buddlers have to clean the buddle and to bring the slimes to it; two laborers cannot, therefore, generally furnish more per shift than 30 hundred-weight of completely concentrated stuff. The work is always done by contract, the price being about 20 cents per hundred-weight of final concentrate.

ECONOMICAL RESULTS OF THE CONCENTRATION.

Pans and dolly-tub.—This treatment of the headings from the round buddle or the blanket-washings saves 9 to 11 per cent. on the average of the amount of gold caught on the plates of the stamp-mill, or 6 to 7½ (average 6¾) per cent. of the gold not caught on the plates. The yield from blanket-washings is better than that from the buddle-headings, since the blankets catch more free gold than the buddle. The former are therefore more frequently used. The cost of extraction of the gold obtained from the dolly-tub is about as follows for 1,000 hundred-weight of rock crushed in the mill:

Wages	$2 40
Interest on capital	1 60
Power, etc	3 00
Total	*7 00

Hand-buddles.—These receive, as has been said, from the round buddles about 13 per cent. of the original weight of crushed material, of the specific gravity 3.55; or, from the launders, (into which, also, the contents of the dolly-tub are discharged,) 20 to 30 per cent. of the original pulp, of the specific gravity 3.2.

In the hand-buddle charge there are, therefore, 40 to 55 per cent. of the contents in ore of the original rock crushed. The loss of ore in buddling is 45 to 50 per cent., and the weight of the concentrate is therefore 4 to 6 (average 5) per cent. of the original pulp, containing, however, on the average, 24 per cent. of the entire ore contents of the pulp.

The cost of buddling for 1,000 hundred-weight of rock crushed is, (by contract, as has been said,) 20 cents per hundred-weight for 50 hundred-weight of concentrate produced, or $10 in all, for conveying the charge to the buddle and buddling.

* That is to say, ore yielding per 1,000 hundred-weight $491 50, (see previous estimates of cost,) in the battery and on the aprons, will yield, say, $49 15 more at an additional expense of $7 for further treatment in pans. Or, ore yielding $9 83 per ton, at a cost of $9 83, will yield by further treatment 98 cents at a cost of 14 cents. When the original ore pays more than expenses, the gain from the dolly-tub is proportionately greater.—R. W. R.

The gold contents of the concentrated tailings amount, on the average, to 10 to 15 per cent. of the gold which has escaped from plates and dolly-tub.

RESULTS OF THE WHOLE TREATMENT.

Gold occurs in the ores of this region, almost universally, not disseminated in the gangue, or at least only so to a very small extent, but contained in the ore proper, both in iron pyrites and (chiefly) in the copper ores, while the zinc-blende and galena contain only silver.*

Very dense iron or copper pyrites in solid masses never contains gold or silver in considerable quantity.†

Auriferous iron pyrites is usually fine-grained, loose in texture, and frequently imbedded in or mixed with pulverulent silica, while the gangue proper is a mixture of quartz and (greenish) feldspar, or even consists of hornstone. The iron pyrites never contains silver in considerable quantity, aside from that which is alloyed with the gold.

The auriferous copper pyrites is very seldom fine-grained like the auriferous iron pyrites. It is occasionally finely disseminated in hornstone, but usually presents crystalline aggregates, with sub-conchoidal fracture, always mixed with aggregates or crystals (usually cubes) of iron pyrites. The crystalline pyrites is traversed in all directions by quartz threads, or mixed with more or less fine granular crystalline silica. The copper pyrites always carries silver as well as gold. Next to copper pyrites occurs most frequently variegated copper ore, containing considerable gold and silver.

With reference to their contents of gold, the veins of this district may be divided into two classes, the total rock hoisted from the first class having an average assay value of $36 per ton of 2,000 pounds, in gold containing 20 per cent. silver, and that of the second class not exceeding $21 per ton. The veins of the first class comprise scarcely one in a hundred of those hitherto developed.

In mines of the first class the rock hoisted (which has a specific gravity of about 3) is sorted, as has been remarked, generally at the time of sending it to grass, and the fragments of richer ore are separated. The weight of the selected ore is 4 to 25 per cent. (average 10 per cent.) of the total mill-rock—*i.e.*, for 900 hundred-weight sent to mill, 100 hundred-weight are reserved as rich ore—and has a market value of $30 to $70 (average, say, $60) for its contents in gold, silver, and copper. The proportion of silver to gold is highly variable; it ranges from one to ten times as much by weight; there may be, on the average, four times as much silver as gold. The proportion of copper is also variable; it bears, however, generally, an approximate relation to that of gold and silver, and may be estimated to average, in the total rock from mines of the first class, 3 to 4 per cent. Under these conditions, the above average selling price of selected ore ($60 per ton) represents an assay value per ton, of—

4.5 ounces gold	$93 00
18 ounces silver	23 40
9 per cent. copper	18 00
Total	134 40

* See my last report, pages 345, 346, *et seq.*—R. W. R.

† This may perhaps be open to question, though Colorado experience thus far goes in the main to support the assertion.—R. W. R.

The only smelting establishment purchasing these ores in Colorado pays at the works 65 per cent. of the full value of the silver and copper, while the price paid for the gold is considerably less, though it rises with the quantity of gold in the ore. For the above proportion of $93, gold, per ton, only about 35 per cent. of its assay value is paid; this gives for the gold $32 80; for the silver, $15 20; and for the copper, $12; or, in all, $60, being 44 to 45 per cent. of the full value.

The cost of transportation of the ore to the smelting-works being reckoned as equal to the cost of hauling to mill, we may assume the average cost of the ore at the works to be $6 per ton.

The mill-rock of the first class, remaining after the selected ore is removed, then contains an average of about 1¾ ounces gold, .800 fine, (20 per cent. silver,) worth $29 40 per ton. The total contents in gold, silver, and copper average about as follows, per ton:

1.4 ounces gold	$28 94
5.6 ounces silver	7 28
2.8 per cent. copper	5 60
Total	41 82

The specific gravity of this mill-rock is about 2.9.

The specific gravity of the rock from veins of the second class is usually in the neighborhood of 2.8. There is here no selection of the best pieces; the whole is sent to mill. The copper contents seldom exceed 2 per cent. The whole valuable contents of these veins is, therefore, estimated, at maximum, per ton—

1 ounce gold	$20 67
4.1 ounces silver	5 33
2 per cent. copper	4 00
Total	30 00

The amount of gold, .800 fine per ton, is therefore 1.25 ounces, or $21.

The proportion of gold in the concentrated tailings amounts, as has been remarked, to 10 to 15 (average 12½) per cent. of the gold escaping from plates and dolly-tub. If the stamp-mill and dolly-tub extract 44 per cent. of the gold in the ore, the concentrated tailings must be only about 1.4 times as rich* as the original mill-rock, while the proportion of ore (sulphurets) in it is 4½ to 6 times as great.

This is due to the small proportion, in the concentrated tailings, of the copper ores, which are the chief carriers of gold. These ores, by virtue of their deficient hardness, are more easily reduced in the battery to very light slime, and thus, together with the finest gold, escape the subsequent concentration, which, not being preceded by a sizing of the particles, can only save the clean granular portions of the charge. The result is, that the proportion between iron pyrites and copper ore in the original mill-rock is changed by the concentration in favor of the former. For the same reason, the proportion of silver, associated with the copper ores, is diminished; but when argentiferous galena is present, as it

* That is, the concentrated tailings amount to 5 per cent. of the weight of original mill-rock, and contain 12½ per cent. of (100—44=56 per cent.) the gold lost from plates and dolly-tub, or 7 per cent. of the original contents of the mill-rock. Being in weight 5 per cent., and in value 7 per cent., they are 1.4 times as rich as the original mill-rock.—R. W. R.

generally is, there is a compensating gain from its collection in the concentrate.

The concentrated tailings contain little or no free gold; and it must, therefore, be inferred that their contents of gold, as well as silver and copper, are due almost entirely to the pulp which was not adequately reduced in crushing.* The amount of gold thus enveloped has been given above at about 15 per cent. of the total gold contents of the mill-rock. The concentrated tailings contain 7 to 8 per cent. The average assay value of concentrated tailings may be set down as follows:

From mill-rock of the first-class, per ton:

2 ounces gold	$41 34
6.5 ounces silver	8 45
1.9 per cent. copper	3 80
Total	53 59

From mill-rock of the second-class, per ton:

1.40 ounces gold	$28 94
3.50 ounces silver	4 55
35 per cent. copper	70
Total	34 19

The smelting works pay for tailings of these grades, respectively, about 21⅔ and 18½ per cent. of the assayed gold value, and 65 per cent. of the assayed silver and copper value; or, for first-class tailings, gold, $8 96; silver, $5 50; copper, $2 48; total, $16 94 per ton; and for second-class tailings, gold, $5 36; silver, $2 96; copper, 46 cents; total, $8 78 per ton.

The cost of hauling from the mill to the smelting works averages about 36 cents per ton.

SUMMARY.

The economical results of the whole mining and reduction may now be presented, according to the foregoing discussion, as follows, calculated upon the basis of 1,000 hundred-weight, or 50 tons of ore:

For veins of the first class:

1. *Selected ore.*

Sale of 5 tons, at $60		$300 00	
Cost of mining and hauling		30 00	
Profit			$270 00

2. *Mill-rock.*

Stamp-mill, (steam-power:)

Yield of the plates, 40 per cent. of $29 40 for 45 tons,		529 20	
Mining and hauling, at $6 per ton	$270 00		
Crushing and amalgamation, at $3 84†	172 90		
		442 90	
Profit			86 30

* Mr. Reichenecker evidently does not believe in any chemical combination of the gold in the sulphurets.—R. W. R.

† More precisely, $3 84.2

Pans and dolly-tub:		
Yield 4 per cent. of $29 40, for 45 tons	$52 92	
Expenses, at 14 cents per ton	6 30	
Profit,		$46 62
Concentration of tailings:		
Sale of 2.25 tons, at $16 94	38 12	
Cost of concentration, at $4 per ton $9 00		
Cost of hauling, at 36 cents per ton 81	9 81	
Profit,		28 31
Total gross profit on 50 tons rock		431 23
From this must still be deducted—		
Costs of administration, say, $1 08 per ton	$54 00	
Taxes, say 18 cents per ton, $9	9 00	
		63 00
Leaving net profit on 50 tons rock		368 23
or $7 36 per ton.		

For veins of the second class:

1. (*Selected ore, none.*)
2. *Mill-rock.*

Stamp-mill, (steam-power:)		
Yield of the plates, 40 per cent. of $21 for 50 tons.	$420 00	
Mining and hauling, at $6 per ton $300 00		
Crushing and amalgamation, at $3.80* per ton, 190 10	490 10	
Loss		$70 10
Pans and dolly-tub:		
Yield, 4 per cent. of $21, for 50 tons	$42 00	
Expenses, at 14 cents per ton of mill-rock	7 00	
Profit		35 00
Concentration of tailings:		
Sale of 2.5 tons, at $8 78	21 95	
Cost of concentration and hauling, at $4 36,	10 90	
Profit		11 05
Gross loss on 50 tons rock		24 05
To this must be added—		
Cost of administration, say, $1 04 per ton	52 00	
Taxes, say, 21 cents per ton	10 50	
		62 50
Giving total loss on 50 tons rock		86 55
or $1 73 per ton.		

* More precisely, $3 80.2. It must be remembered that the figures of expense per ton are deduced from the cost per 50 tons. Otherwise these fractions would be absurd. The cost of crushing and amalgamation, it will be seen, is 4 cents less for second-class than for first-class rock, on account of the diminished consumption of quicksilver.—R. W. R.

The employment of water-power instead of steam effects a saving in running expense per 50 tons of about $84 50 in crushing, and $2 at the pans and dolly-tub, or, in all, $86 50, which would reduce the loss in treating second-class rock to 5 cents on 50 tons, or practically nothing.

The gross receipts from rock of the first class are about 36.24 per cent., and from rock of the second class about 32.13 per cent., of their total assay value in gold, silver, and copper.

The average of profit determines the value of the mine. A daily product of 12½ tons, or an annual product (reckoning three hundred working days to the year) of 3,750 tons, employing twenty to twenty-five stamps of the average weight of 450 pounds, and run by steam, represents, for veins of the first class, all the rock brought to grass having an average assay value of $50 80 per ton, an annual profit of $27,620. The capitalized value of the mine, at 10 per cent., would therefore be about $276,000.*

For veins of the second class, with a maximum average assay value of $30 per ton, it appears that reduction with steam-power entails a loss, while in water-mills the rock about pays expenses. The ownership of such a mine is therefore, under present conditions, not profitable, unless it is combined with complete concentrating works; though, of course, it is an economical benefit to the community and the country to keep it going, if it pays only expenses. From another point of view, it is worth the owner's while to open up his mine,† as its value will thereby be increased when more favorable conditions occur, such as the reduction of running expenses, by the fall of wages and prices of supplies, or the increase of the yield, by the introduction of more perfect methods of concentration.‡ These ameliorations must necessarily be effected at no very distant day in Colorado.

The quantity of pyritic gold ores annually treated in Colorado at the present time probably does not exceed 100,000 tons, and their treatment in the manner described employs directly about 270 workmen in the mills and concentrating works.

AMALGAMATED COPPER PLATES.§

The discovery of the utility of amalgamated copper plates in the treatment of auriferous rock in the stamp-mill has so simplified and cheapened the metallurgy of gold that it is now profitable to mine and reduce many gold-bearing ores and rocks that formerly would not pay the necessary expenses of manipulation by the old processes of amalgamation in arastras, Chilian mills, amalgamators, barrels, etc. By the aid of the plates, in a majority of cases it is made unnecessary to submit the ore to a separate and distinct amalgamation after the operation of pulverizing, with all the attendant expenses of handling, loss, wear and tear of machinery, power, loss of quicksilver, etc. Instead, the amalgama-

* The calculations of expense, as we have seen, include a liberal allowance for interest on capital invested in machinery. Nevertheless, 10 per cent. is too low a rate for the capitalized value of the mine, since this capital is consumed, and should pay, besides 10 per cent. of net profit, at least 5 per cent. to a sinking fund, so to speak.—R. W. R.

† This is true so long as the operations do not materially encroach upon the reserves of ore; but after a certain time the "development" of a mine means its progressive exhaustion.—R. W. R.

‡ Or, I would add, the possible disclosure, by underground workings, of better grades of ore in the mine.—R. W. R.

§ This treatise on the copper plates, which was prepared for me by Mr. N. S. Keith, is introduced here, instead of earlier, in order not to interrupt Mr. Reichenecker's contribution, which closes at this point.

tion takes place in, as it were, the same apparatus which effects the reduction, and in a practical and effectual manner. This is the case, of course, after the gold is freed from its matrix. These virtues are not claimed in the case of ores in which the gold is mineralized (if there are any such) or covered by substances which prevent the contact with quicksilver.

The principal difficulty with which the millman has to contend is the discoloration of the surface of the plate by oxides or various insoluble metallic salts, when it is so necessary to keep it bright and free from any film or covering preventing the easy and sure contact and adhesion of the particles of gold and amalgam as the pulp passes over. A new plate, then, is not considered in "taking condition" until it will remain bright for at least some hours without "dressing." With most plans of preparation this desideratum is not attained before a firmly-adhering layer of gold amalgam has attached itself to the plate, which usually takes place after the loss of much gold, labor, and time. Silver-plated, and even gold-plated copper plates have been used, but have not met with much favor, being either ineffectual or too expensive. The following-described plan of preparation and treatment I have found most effective, and at the same time inexpensive, as compared with silver-plating.

Composition plates made of copper, with a small quantity of zinc, have been used. Though they are very easily kept clean and are effective, they have been found too expensive, as they are easily broken. Their brittleness is caused by the union of the quicksilver with the zinc alloyed with the copper.

The conditions necessary to be observed in the preparation and care of amalgamated copper plates, that they may be put and kept in most effective order, are these: Quality of copper; method of amalgamating the plate; method of "dressing" the plate; purity of mercury; purity of water; character of ore or rock. In selecting the plate, take only the purest, softest copper, free from dark, rough spots of iron, etc. The quality known to the trade as "braziers' copper" is the best from which to select the pieces. Do not take that which has been rolled with special care to make the surface smooth and hard, as that will not absorb the quicksilver so well as the softer and consequently more porous. It is best, for efficiency and durability, to select plates weighing not less than three pounds to a square foot; thicker is better. For inside plates use that which is two or three times as heavy, as not being so easily bent and torn from position. If possible, buy copper which has been annealed subsequently to the last rolling. If not, then anneal the plates by exposing them to heat on the under side, sufficient to ignite sawdust laid upon the upper side. This may be done over a blacksmith's fire, but more handily over an open fire of wood or charcoal. Be sure to subject every part of the plate to the heat. This will soften the plate, making it more porous, and consequently capable of retaining more quicksilver and amalgam that it otherwise would. As the efficiency of copper plates is in proportion to their ability to hold quicksilver, this point must be carefully attended to. After this, straighten the plate by laying it on the table and using a wooden block and hammer. Do not strike with the hammer directly on the plate, but interpose the block, so that the face of the copper may not be compressed or drawn out of shape. Fasten then to the table with iron screws, or, preferably, copper nails long enough to clinch on the under side of the table. In either case, have the heads of screws or nails flush with the face of the plate. Do not use brass screws, as quicksilver soon penetrates and makes brittle the heads,

so that they will not hold. The minor inequalities may now be removed by the use of the block and hammer.

Next scour the plate with wood ashes and fine sand or tailings, using a scrubbing-brush or coarse rag. Bad spots may be scoured with the ashes and sand, and the end of a small block of wood. Continue the scouring until the coating of oxide is entirely removed and the bright, metallic copper exposed. Caustic soda, the concentrated lye of the shops, or sal-soda, may be used instead of ashes, the object being to remove all traces of oil or grease by action of alkalies. After washing with clean water, apply with a soft brush, or swab, a solution of cyanide of potassium, say, one-half ounce of cyanide to a pint of water. The plate may be readily amalgamated by the use of the following mixture: Fine sand or tailings, powdered sal-ammoniac, equal parts, and containing a small quantity of quicksilver sprinkled therein. With the scrubbing-brush and this mixture continue the scrubbing until all parts of the plate are amalgamated. During the operation, sprinkle on the plate as much quicksilver as the plate will absorb, and water enough to make a thick mud of the mixture. I have used lime with this mixture, but cannot say that the addition is of any special benefit. It is unpleasant, to say the least, as ammonia is set free in great quantity. Allow this mixture to remain on the plate for an hour or so, and then wash it off with clean water and the brush. Follow with the soft brush and cyanide solution, adding quicksilver, if the plate will hold it. By continuing this treatment for three or four rounds, the plate will be found to have taken up or absorbed as much quicksilver as ordinarily after many weeks' running. If fine gold amalgam can be spared, it is well at this stage to rub some upon the plate, using a cloth rubber wetted with a solution of sal-amoniac, in the proportion of four ounces to the pint of water. If the amalgam be heated and rubbed in a wedgewood mortar, so as to insure the solution or minute diffusion of the gold, it will be the more readily attached to the plate. I have used silver amalgam in the place of gold amalgam, with excellent results. Silver amalgam can be made as follows: Dissolve a piece of silver—coin will answer—in the smallest possible quantity of dilute nitric acid. Heat will hasten the solution. Dissolve the resulting crystals of nitrate of silver in water, and pour into the vessel enough quicksilver to reduce and amalgamate the silver in the solution. This reaction will be completed in a few hours. Wash the amalgam with clean water, to remove all traces of nitrate of mercury, and strain to remove the surplus quicksilver, leaving in the cloth a pasty amalgam of very pure and finely-divided silver. Use this as directed for the gold amalgam.

The *rationale* of this plan of treatment may be stated as follows: The first scouring removes oxides and grease, and exposes the pure, bright metal, which by the annealing has been rendered capable of holding a comparatively large quantity of quicksilver and amalgam, by virtue of its porosity. The sal-ammoniac, by reason of its property of dissolving oxides, assists the amalgamation by keeping a bright metallic surface, allowing the quicksilver and amalgam to penetrate the copper, filling the minute interstices, and combine in atomic proportions, so as to form an alloy of copper, gold, and quicksilver. Thus the air, water, and various salts are kept from acting directly upon the copper, preventing the formation of oxide and carbonate of copper to coat the plate. This is accomplished in a longer or shorter period, depending upon the mode of preparation and upon the richness of the ore and the ease with which the gold in the ore may be amalgamated. It is probable that the galvanic current due to the contact of two dissimilar metals plays

an important part in influencing the chemical reactions and assisting the amalgamation of gold, but as its exact action is not defined it is needless to discuss the point in this article.

The point aimed at in this plan of preparation is to hasten the union of a sufficient amount of gold and quicksilver with the copper. If allowed to take place slowly, the unavoidable loss of gold makes the expense much greater than if forwarded by the use of the needful amount of amalgam, before running any ore over the plate. If an old, well-used plate be cut or broken the amalgam will be found to have penetrated perhaps half, and in some cases completely through the copper.

Corrosive sublimate, nitrate of mercury, sulphuric acid, and common salt, muriatic acid, sodium amalgam, cyanide of potassium, and other acids and salts, have been used in amalgamating copper; but though the amalgamation may be accomplished in some cases quite easily, the plate cannot be brought to a good working condition so soon, if at all, as in the way described.

The subsequent treatment of plates, amalgamated as described, should be varied to suit the circumstances of kind and quality of ore, and purity of water. Water containing carbonic acid discolors plates readily, forming an insoluble coating of carbonate of copper. Though an infinitely thin film, it is sufficient to prevent the contact and adhesion of gold and amalgam, unless in particles sufficiently large to break the coating. The worst form of discoloration of plates proceeds from the action of sulphates or iron and copper present in many ores from the natural decomposition of the pyrites. The addition of lime to the water introduced to the battery, as much as will dissolve therein, will neutralize the carbonic acid and decompose the sulphates. It may be necessary to add lime to the ore to furnish enough to react on all the sulphates.

When the mill is in operation the plates should be "dressed" every six hours, or oftener, should they become discolored. After stopping the mill and washing the plates with a stream of clear water, apply with a soft brush (a whitewash brush is handy) some of the solution of sal-ammoniac. Allow the sal-ammoniac to remain on the plate a few minutes, wash with clear water, and apply with the brush enough of the solution of cyanide of potassium to brighten the plate. The plate should have upon it as much quicksilver as it will hold without gathering in drops or running off. Experience in this matter will teach the niceties of manipulation to the millman.

It is essential to use quicksilver entirely free from "base metals," such as lead, zinc, tin, copper, etc. The presence of gold and silver is, of course, desirable. The base metals, when combined with quicksilver, oxidize very readily, especially when the amalgam is finely divided, exposing a large surface to the action of water, air, and other oxidizing agents. Thus, with impure quicksilver the coating on plates may arise from the amalgam, instead of the copper itself.

To test the purity of quicksilver, put a small quantity on a sheet of paper while dry; if, when moved upon the paper, by inclining it in various directions, a film adhering to the paper is left on the track, the quicksilver is impure. Another test: Put a half an ounce or so in an ordinary iron "gold pan," and by a quick up and down jerk separate the mercury into small globules; if, on inclining the pan, they do not readily run together, the sample is impure. To purify, first retort the quicksilver, and add to it after retorting a few ounces of dilute nitric acid, (acid, one part, water, three parts.) An ordinary acid bottle is a handy vessel to hold the mercury and acid, as it may occasionally be agitated to hasten the purification by bringing the acid in contact with the im-

purities. The acid, by reason of its greater affinity for the base metals, removes them by forming nitrates. The chemical details I need not enter into in this article. Some days may elapse before the quicksilver becomes purified. Samples may be tested from time to time by the plans I have mentioned. Before using the quicksilver it should be repeatedly washed with water to remove all traces of nitrates. It is a good plan to keep a supply of quicksilver under treatment, putting all which has been used into the bottle, and drawing from it such an amount of purified as may be wanted.

A stock of needful chemicals should be kept at the mill. The following list comprises those necessary for the preparation and treatment of plates and quicksilver: Cyanide of potassium, (fused,) sal-ammoniac, (powdered,) caustic or unslacked lime, caustic soda or "concentrated lye," and nitric acid, (commercial acid is sufficiently pure.) Cyanide of sodium may be substituted for cyanide of potassium; common salt for sal-ammoniac; wood ashes, or the lye therefrom, or sal-soda, for the lime and soda, and sulphuric acid and saltpeter for nitric acid. These substitutes are but "make-shifts" at best, and consequently should not be used when the others are at hand or can be procured. It is well to keep ready prepared the solutions of sal-ammoniac and cyanide of potassium in well-stoppered bottles. The cyanide solution being especially liable to decomposition, should not be prepared in large quantities at a time. It should also be carefully kept and labeled as *poison*, to prevent accidents.

THE ABSORPTION OF SULPHUR BY GOLD.

Mr. William Skey, analyst to the geological survey of New Zealand, has published an interesting paper on the absorption of sulphur by gold, and its effects in retarding amalgamation. While investigating the causes of the reported loss of gold during the process of extraction at the Thames gold fields, he observed that much of this loss could scarcely be referred to any of those causes generally supposed operative for it. He therefore tested the actual condition of the natural surfaces of numerous specimens of Thames gold, in respect to their behavior with mercury, and examined further than has hitherto been done into its comportment with several of those substances likely to be associated with it in a natural way.

The results of these examinations are minutely recorded in his paper, and the following short abstract of them is taken from the London Chemical News. The author finds—

1. That numerous samples of bright, clean-looking gold, of all degrees of fineness, refuse to amalgamate on any part of their natural surfaces, though taken directly from the reef and untouched by hand.
2. That on such surfaces sulphur is always present.
3. That native gold, or gold in a pure state, readily absorbs sulphur from moist sulphureted hydrogen or sulphide of ammonium, and absorbs it directly when administered in boiling water.
4. That surfaces so treated refuse to amalgamate, though no apparent change can be observed in their aspect.
5. That gold so affected is rendered amalgamable by roasting in an open fire, unless copper is present to the extent of seven per cent., (or perhaps less,) while the same effect is produced by the contact of cyanide of potassium, chromic and nitric acid, and chloride of lime acidified.
6. That this absorption is altogether of a chemical nature.
7. That sulphates of iron, in presence of air and water, decomposed various metallic sulphides common to auriferous reefs, in such a manner as to liberate sulphureted hydrogen.

The action of sulphureted hydrogen upon gold, in rendering it non-amalgamable when

placed in contact with mercury, was demonstrated with striking effect by the author before the members of this society.

From these results the author has been led to suppose that a large area of the natural surfaces of native gold is covered with a thin film of an auriferous sulphide, and that the greater part of the gold which escapes amalgamation at the battery is represented by that portion of this sulphurized gold which has remained unabraded during the processes of milling or extraction from the reef; the state of the gold, rather than that of the mercury, therefore, being the greatest impediment to thorough amalgamation.

In addition to these results, the author communicated others relative to the effect of solutions of sulphureted hydrogen and sulphide of ammonium upon platinum. In rendering it non-amalgamable, he believed a sulphide of the metal had formed in each case, since chromic acid rendered it again amalgamable. He also stated that this metal is also so affected by ammonia or the fixed alkalies that it will not amalgamate, except in presence of a mineral acid, from which he suspects platina is capable of superficial oxidizement when in contact with alkaline substances, even at common temperatures. The author found that his samples of gold were not affected by the alkalies in this manner, except in the case of one from Victoria, a singularity from which was argued the presence of palladium in this particular sample.

SMELTING.

The treatment of the first-class selected ores is effected principally in the works of the Boston and Colorado Gold Smelting Company, in Gregory Gulch, below the town of Black Hawk.* This establishment, under the direction of Professor N. P. Hill, purchases selected ores and tailings, and treats them for the extraction of gold, silver, and copper. These metals are obtained, however, in the form of "matte," consisting mainly of the sulphide of copper with sulphide of iron, and containing, when concentrated, from 50 to 60 per cent. of copper, and gold and silver in varying proportions, generally 40 or 50 ounces of fine gold, and from 100 to 400 ounces of fine silver per ton of matte. In this form it is shipped to Swansea, in Wales, for further separation and refining; but it is expected that the necessary additions for these processes will be made to the works at Black Hawk, and that the whole reduction will be performed there.

The matte-smelting here employed is not essentially different from the European method. As all smelting processes require to be conducted by experts, and as it is impossible to discuss the details of so complicated and technical a subject in a general report, which is not intended as a text-book, a mere outline of the successive operations involved in matte-smelting, as practiced in Colorado, must here suffice.

The ores, as they ordinarily occur, (peculiar cases aside,) consist essentially of iron and copper pyrites, with a silicious gangue, carrying from 3 or 4 to 10 or 12 ounces of fine gold per ton, and silver in more variable quantity—usually 2 ounces of silver for 1 of gold, but sometimes much more.†

In the smelting process, the object of which is to separate the copper, and with it the gold and silver, from the earthy gangue, the sulphur plays an important part, since the resultant regulus, or matte, is to contain the copper as a sulphide, while a large portion of the iron and other foreign elements are removed in the slag. An excess of sulphur brings too much sulphide of iron into the regulus, which is thereby impoverished in quality though increased in quantity. A lack of sulphur allows a portion of the copper to become scorified, or taken up in the slag. To

* This description of the matte-smelting process is condensed from the report of Mr. J. D. Hague, U. S. Geol. Exp. Fortieth Parallel, vol. iii.

† General average, according to Mr. Reichenecker, 4.5 ounces gold, 18 ounces silver, and 9 per cent. copper.—R. W. R.

avoid the former evil, the ores are roasted to expel a portion of the sulphur and partially oxidize the metals. If too little sulphur is left after roasting the proper proportion can be restored by the addition of raw ore in mixing the charge for smelting.

The proper mixture of the charge demands great skill and judgment, and an intimate knowledge of the particular material under treatment. The proportions must be such as to secure complete chemical reactions and combinations, and to avoid certain mechanical evils. For instance, the formation of a liquid slag must be insured, since if the slag is too thick it will prevent the complete precipitation of the regulus.

The principal operations at the works consist in the preliminary preparation of the ores, such as the breaking, weighing, sampling, and assaying of the respective lots, roasting of the hand-broken ores in heaps, and of the mill-tailings in reverberatories, crushing by rollers of the roasted ore, smelting to regulus, and the final crushing, packing, and shipment of the latter.

The ore, when first received, is spalled by hand to the size of a man's fist, or somewhat less, and carefully sampled for assay, in the following manner: The ore is shoveled, for removal to the roasting-heap, into barrows, each of which will contain 200 pounds, and standing balanced on a scale. From each barrow, or alternate barrow, a shovelful is taken and reserved as a sample. When any given parcel of ore has been thus broken and weighed the accumulated samples are taken together and sufficiently reduced in fineness to pass through a No. 4 screen, (four meshes to the linear inch.) The material, having passed through this screen, is arranged in a conical pile and divided into quarters, of which two, diagonally opposite, are taken and reduced to pass through a No. 8 screen. These screenings are again quartered, and two opposite quarters are reduced to pass a No. 20 screen, and the operation is repeated, reducing the fineness to that of a No. 40 screen. From this result a final sample is taken, reduced to No. 80, and then assayed for gold, silver, and copper. Upon this assay the ore is paid for, according to the established scale of prices, or on special agreement.

In shoveling the ore into the barrows it is thrown on a screen, by means of which the finer portion is separated from the coarse pieces and reserved for covering the latter when laid up in heaps for roasting.

The heap-roasting in the open air is a slow but comparatively cheap process. A single heap usually contains some 30 or 40 tons of ore, and requires five or six weeks for the operation. A bed of cord wood, about 16 feet square, is laid as the base, the first course, of thick billets, being laid directly on the ground, the billets parallel, but a little apart, to permit the passage of air, and the overlying courses being laid crosswise and more closely, forming a bed 5 or 6 inches in height and requiring altogether about a cord of wood for each heap. A wooden chimney, 9 or 10 inches square, is set vertically in the center, passing down through the bed of fuel and reaching above the top of the heap. A small quantity of charcoal is put at the bottom of this box-flue, and the heap is ignited, when ready, by setting fire to the coal. The ore is piled upon this foundation, around the chimney, the larger pieces being placed inside, and the whole covered on the outside with a layer of fine stuff, so disposed as to control the rate of combustion. If this is too slow in any part, the covering can be opened to give greater draught; if too rapid the covering is made closer. The only attention required during roasting is directed to the rate of combustion. Too rapid a rate slags or sinters the ore; too slow a rate causes imperfect calcination, or may allow the fire to go out altogether, involving rehandling, with loss of

time and money. To break the ore, weigh it, wheel it to the yard, and lay it up in heaps, costs $2 30 per ton.*

Tailings, owing to their finely pulverized condition, cannot be roasted in heaps, and must be treated in calcining furnaces, of which there are two; they are about 30 feet long by 10 feet wide inside. The fire-place, separated from the hearth by a bridge about 15 inches high, is at one end of the furnace, the flue at the other end. The bottom is flat, consisting of a single course of common brick, laid on a solid stone or rubble foundation. There are three sections of hearth, on slightly different levels; the first, about one-third of the total length, and farthest from the fire-place, is about 4 inches higher than the middle, which is in turn about 4 inches higher than the section next the fire-place; the sides are little less than 2 feet high, and the top is slightly arched from side to side. In one side of the furnace are six small doors, through which the charge is introduced and stirred while in the furnace. The charge, being put in the end most remote from the fire-place, is gradually heated on the highest hearth, and, as the charges preceding it are advanced, it is moved on to the next hearth, making room for a new one, and so on, until on the third or lowest hearth, next the bridge, it is subjected to the highest heat. Each charge consists of from 1 to 1½ tons, and three charges are put in during twenty-four hours, each charge remaining on each hearth nearly three hours. While in the furnace the charge is constantly stirred. Two men are required on each shift for each furnace; and one cord of wood is consumed in twenty-four hours. The capacity of each furnace is from 3½ to 4 tons per day. The costs of treatment are said to be $5 per ton. Two Gerstenhöfer or Terrace furnaces were built some years ago for calcining, but have never been satisfactorily operated, owing, it is said, to the poor quality of the fire-brick employed for the terraces.

The ore from the roasting-heaps is crushed by a pair of Cornish rollers, 26 inches in diameter, and passed through a No. 4 screen, after which it is carried to the smelting furnace. This is a reverberatory, resembling those employed in England for copper smelting. The hearth is fourteen feet long by 9½ feet wide inside, of oval shape, with the small end nearest the stack. The foundation is stone, with a vaulted space under the hearth. The fire-grate is 5 feet by 4 feet; the fire-bridge 18 inches high; and the space between the fire-bridge and the arch, 18 inches. The arch slopes toward the hearth at the opposite end, leaving a mean height of the chamber of about 2 feet. The slag is removed through a working door near the stack, which stands at one corner of the structure, connected with the interior by a flue. A cast-iron skimming-plate, 9 inches thick and 8 or 9 feet long, forms the sill of the door. The feeding door is on one side of the furnace, opposite the tap. The slightly concave hearth slopes toward the tap. The concavity is but a few inches below the skimming-plate. The bottom is made by first laying upon the prepared foundation a flat floor of fire-brick, about two feet below the surface of the hearth; this is covered with a layer of finely powdered flint, which, after strong heating for several days, is again pounded, and covered with another layer of the same material mixed with slag, the sides of the furnace are 12 inches thick; the top is one course of brick, set on end. The whole structure is tied together by means of tim-

* By the system of heap-roasting, the sulphur expelled from the ores is of course lost; nor are any means for utilizing the sulphur attached to the reverberatories. The complete process, which will doubtless be introduced when commercial and industrial conditions warrant, will comprise the production of sulphuric acid, for sale, or for use in the extraction of the precious metals.—R. W. R.

bers connected by iron rods. The stack is 54 feet high, 27 inches square at the top, and increasing slightly toward the bottom.

The charge is about two tons, consisting of different grades of calcined ore and tailings, with sometimes a little raw ore or some rich slags of previous meltings, so mixed as to secure the desired proportions of silica, iron, copper, sulphur, etc. Six or seven hours, and sometimes more, are required for the reduction of each charge. When finished, the slag is raked out through the skimming door and cast in sand-molds; these are broken up and carefully inspected; the portion on the bottom which shows adhering particles of matte must be remelted; that which is sufficiently poor is thrown away. The matte remains in the furnace until, after repeated charges—generally four or five, consuming eight to ten tons of ore—about a ton has accumulated, when it is drawn off through the tap and cast in sand-molds. Under favorable conditions each furnace may yield one ton of matte per day; but this is above the average. If made from the best ore, the matte is rich enough to ship after the first melting; but the greater portion is not up to the standard, and must be remelted. Under existing conditions it is desirable to produce for shipment a matte that contains about 50 per cent. of copper, with 40 or 50 ounces of fine gold, and between 100 and 200 ounces of fine silver, per ton. The loss in smelting for the production of matte is said not to exceed 5 per cent. of the assay value of the ore.

Each furnace runs night and day, requires two men constantly, and four when charging, and consumes daily from ten to twelve cords of wood, costing $6 per cord. The matte is finally broken in the crusher, passed through the rollers, sewed up in small sacks of stout canvas, and shipped to Vivian & Co., of Swansea, Wales. The cost of packages, handling, freight, commissions, etc., not including that of further treatment, are stated at about $120 per ton of matte.*

The prices paid by Professor Hill, previous to January 1, 1870, are shown in the following schedule, which was not, however, invariably adhered to.

Ounces of fine gold, per ton of 2,000 pounds.	Percentage paid of the value of the gold and copper.
10	60
9	58
8	55
7	52½
6	50
5	45
4	40
3	30
2	20

In calculating the value of ore according to the above scale, the ounce of fine gold is reckoned at $20, coin, and the unit of copper at $2. The copper unit, however, is reckoned on the English ton; and as the ores are assayed and purchased by the short ton, a deduction of 12 per cent. is made on the copper assay. Thus, if an ore is found to contain 8 per cent. or units of copper, worth, according to the above scale, $16, a deduction of 12 per cent. is made, to adapt it to the English ton. Moreover, the copper is determined by wet assay, from which 1½ per cent.

* It is expected that the value of the copper will cover this cost, and likewise that of the subsequent gold and silver extraction, leaving the value of the gold and silver as net return to the works in Colorado.—R. W. R.

is to be deducted for working loss, so that if the percentage of copper contained in an ore does not exceed 1½, no account is taken of it in paying for the ore.

In addition to these rates for gold and copper, the silver in the ore was paid for at the rate of 75 cents per ton, after deducting from the number of ounces contained per ton as many ounces as there were units of copper—the rule of the Swansea works.*

Since January, 1870, these works have raised the prices paid for ores.†

The first shipment of matte was made from these works in June, 1868. Complete statements of the shipments made since that time are not available. They are estimated, up to the close of 1869, at about 25 tons of matte per month, containing, on the average, 40 ounces of fine gold, 200 ounces of fine silver, and 40 per cent. or 800 pounds of metallic copper, per ton. The gross value of these metals would be therefore about $30,000 dollars coin per month, or $570,000 from the date of beginning to the end of 1869.‡

GENERAL REVIEW.

The following contribution to this report, from the pen of Mr. A. Von Schulz, a very intelligent and well-educated metallurgist, of Central City, is published in full, as interesting and suggestive, though it covers, in some particulars, matters already touched upon, and advances views with regard to the metallurgical application of the Colorado coals, and one or two other points, which I am not quite prepared to accept, since, though plausible, they lack experimental proof, so far as I am now informed:

According to the occurrence and behavior of gold in these ores, they are classed as decomposed ores and sulphurets. In the former the gold is disseminated in a free and metallic state, and can therefore be beneficiated by simple amalgamation. In the sulphurets the greatest part of the gold is present in that peculiar form, the nature of which is not yet sufficiently defined. When in this state it cannot be extracted by common amalgamation.

A natural consequence of this geological occurrence was the introduction of stamp-mills in the course of the development of the Territory. With these the gold con-

* The complicated system of prices, perquisites, and deductions employed by smelters in calculating their payment for ores, is justly complained of by the miners, as serving merely to bewilder the seller and conceal the profits of the buyer. Many items might be simplified in the interest of fair dealing. The theory, however, is correct, that the prices paid for ores must be graduated, not merely according to their actual contents in valuable metals, but with reference also to the grade and character of ore, as influencing the cost of reduction. It is probable, that on the foregoing schedule Professor Hill lost something in the purchase of the lowest grades, and made it up on the rich ores. Indeed, he would doubtless refuse to purchase 2-ounce gold ores, did he not require them, in the absence of cheaper fluxes, to mix with the others.—R. W. R.

† At the time of my visit, in the autumn of 1870, I was told that no regular schedule was followed. I heard of instances in which $5 per ton was paid for tailings, containing 1 to 1½ ounces of gold. The developments in Grand Island district having made silver ores an important part of the supply of the works, the prices paid for silver had been advanced, possibly to prevent shipments of ore to the East. For 100-ounce silver ores, 80 cents per ounce was paid, and for very rich ores, as high as $1 30 currency—a deduction of $50 per ton being made, however, for the cost of reduction. Probably these works, being well established and commanding large capital, could afford to advance prices still further, if competition should require it; a consideration full of warning to the eager projectors of rival establishments.—R. W. R.

‡ It is estimated that the shipments of 1870 amounted to 520 tons—that is an average of ten tons weekly—worth at least $170 per ton, or $884,000 for the gross value of the shipments for the year. This estimate appears high to me, but it is pronounced low by those who are in a better position to judge; and, as official returns from the works are not available, I have accepted it. The increase is due to the enlargement of the works and the treatment of rich Caribou ores.—R. W. R.

tained in the decomposed ores was extracted according to the method practiced in California, by catching it on amalgamated copper plates. But the more decomposed ores were extracted from the mines and the more sulphurets took their place in depth the more this method appeared insufficient and the want of a better one for the purpose became apparent. This caused all those experiments and enterprises which, inaugurated from 1863 to 1866, never came to a successful conclusion. Instead of imitating the old methods, proved successful in Europe, new ones were desired; instead of common sense and metallurgical knowledge, ingenious schemes, entirely independent of scientific facts, became the order of the day. It was only natural that the loss of the enormous sums invested should be followed by depression. Finally the old stamp-mills, with amalgamation on copper plates, were reinstated, or the mines were closed until proper methods for the beneficiation of the refractory sulphurets should come into use. On the whole, those companies which chose the latter course have acted most wisely; for although the cost of running stamp-works is small, they must be decidedly rejected, considering them from the stand-point of national economy, when the beneficiation of rich auriferous sulphurets is desired, as hardly 30 to 40 per cent. of the gold contained in such ores is saved by this treatment.

About four years ago Professor Hill, at Black Hawk, commenced smelting the sulphurets into copper matte, following the old methods universally in use in Europe. He sends this product to England for the separation of the gold, silver, and copper. From the first hour of its commencement to this day, the enterprise has been uniformly successful, and it is now intended to enlarge the capacity of the works for the third time. This exerted a most beneficial influence on mining. New vigor seemed to inspire the whole interest; and the tailings, formerly lost from the mills, have since been caught, concentrated, and sold to the smelting works, where they were welcome as a flux, it being impossible to get lime for the purpose at less cost.

As a drawback to enterprises of this kind for the beneficiation of the sulphurets, it is urged that they require a large working capital, and can only be profitably conducted on a large scale. But this is rather an advantage than otherwise; for large enterprises, conducted with success, benefit directly and visibly the whole community, while small smelting-works hardly ever prosper nowadays.

The greatest advantage of the smelting method over the mill process lies in the fact that by it almost all the gold and silver, as well as the copper, contained in the ores is saved. To be sure, only the rich ores can be treated in this way at present; but as soon as Gilpin County is connected with the coal-fields of Colorado by rail it will also pay well to mine the less rich ores, to concentrate them, and to ship them to the smelting-works. Stamp-mills can, of course, never be dispensed with altogether. They are the cheapest appliances for working the remainder of the decomposed ores; and in the future, after the introduction of a rational system of dressing-works, they will serve for the beneficiation of the tailings from the dressing-works.

About a year since another method, Plattner's process of extracting gold by chlorine gas, was introduced in Gilpin County. The enterprise being limited as to capital, and the process hindered by the other metals present, it has so far given satisfactory results only in regard to the fineness of the produced gold. To make the Plattner process adequate to the requirements of Colorado sulphurets, it will have to be modified by adding, after the roasting and chlorination, a process by which the copper can be extracted and the silver separated at small cost.

To render more valuable the ores of medium grade the introduction of ore-dressing is required. Cylinder-crushers, sieves for the separation according to size, and jiggers are the only machinery necessary; and in case of the scarcity of water, that supplied to the jiggers can be used over and over again. The ore should not be crushed finer than to a size of 2 millimeters. The tailings should be treated in the stamp-mills, or in large arrastras, which can very well compete with mills on a large scale, and have, besides, the advantage of a higher yield.

Real and continuous success of the Gilpin County gold mines can only be expected after the completion of the railroad to Golden City and its coal-fields. In the present state of metallurgy, the lixiviation with sulphuric acid is probably the cheapest and best method for working Colorado gold-bearing sulphurets. If, besides the reverberatories necessary for the production of copper matte, a blast-furnace was added, for lead-smelting, the silver ores from Clear Creek County might at the same time be treated either thus or by the Patera process, according to their larger contents in lead or pyrites.

The products thus gained would be sulphur, copper, lead, silver, and gold, and in the lead-works the lead-matte occurring at Golden and Boulder Cities might also be profitably worked.

After the establishment of such a work these petty dissensions between the different mining companies, which at present hinder so much the development of the Gilpin County mining interest, would also cease. Whenever the contemporaneous execution of the four processes above mentioned is insured, and this in the coal-fields and among the water-powers between Golden and Boulder City; when that region is connected with Gilpin and Clear Creek Counties by rail; when the Territorial mining laws are

revised and improved; then the two counties mentioned, with their great abundance of veins, even if they furnish only poor or medium ores, cannot fail to reach a development such as is known to very few districts on this continent.

DRY CONCENTRATION.

Colonel G. W. Baker, of the Central City Herald, published during the summer of 1870 a series of articles on the Colorado treatment of gold ores, which aroused considerable feeling throughout the Territory. So for as their exposition of the losses incurred by the mill-process is concerned, they appear to be well-founded. The plan suggested as a remedy comprises dry crushing, dry separation, and chloridizing roasting in the Stetefeldt furnace, with subsequent amalgamation. For the separation, Krom's dry concentrator is proposed—an excellent machine, and probably the best of that class.

The following account, published by Colonel Baker in July, describes one of several experiments made in Gilpin County, with a view to test Krom's machine in the separation of pyrites from gangue.

HERALD OFFICE, *June* 26, 1870.

GENTLEMEN: Will you please give personal supervision to the separation of some mill tailings now at the Lexington mill, the separation to be done in your presence by the Krom machine, and observe the inclosed instructions, and report according to the schedule to

Yours, very respectfully,

G. W. BAKER.

To Messrs. E. E. BURLINGAME, A. VON SCHULZ, *Assayers.*

INSTRUCTIONS.

1st. From the pile of mill tailings procure sufficient samples for assay, and then, after weighing the remainder, see it passed through the machine.

2d. Weigh the headings; assay same for per cent. of gangue; assay same for gold and silver.

3d. Take sample of the *separated* tailings, assay same for metal left; assay same for gold and silver.

4th. Sieve the sample of original tailings for degree of fineness; assay same for per cent. of metal; assay same for gold and silver.

TERRITORIAL ASSAY OFFICE, *Central City, June* 30, 1870.

DEAR SIR: In accordance with your request Mr. Schulz personally sampled the tailings, weighed the lot, (found to be exactly thirty pounds,) remained whilst they were separated, and brought away the headings and a sample of the separated tailings. The packages were numbered as follows:

1st. Package of mill tailings.

2d. Package of machine-separated headings.

3d. Package of machine-separated tailings.

The following is the result of tests made according to instructions:

1st. 44 65-100 per cent. of the mill tailings (package No. 1) passed through sieve, 120 meshes to linear inch, or 14,400 to the square inch; 85 per cent. passed through sieve, 80 meshes, or 6,400 to the square inch.

2d. An acid assay of sample (package No. 1) showed contents to consist of, gangue matter, 58 3-10 per cent.; pyritous matter, 41 7-10 per cent.

3d. Separated headings (package No. 2) weighed 9 7-10 pounds; acid assay of sample resulted in leaving 8 2-10 per cent. gangue; pyritous, 91 8-10 per cent. of mass.

4th. Machine-separated tailings (package No. 3) by acid assay left, of gangue matter, 90 6-10 per cent.; contained pyritous, 9 4-10 per cent.

5th. From the thirty pounds 32 3-10 per cent. of pyritous matter was separated by one operation, leaving 9 3-10 unseparated.

ASSAYS.

Assay of package No. 1, mill tailings, $6 20 gold; $4 81 silver—Total $11 01.
Assay of package No. 2, machine headings, $22 83 gold; $10 85 silver—Total $36 68.
Assay of package No. 3, machine tailings, a trace of gold, $1 76 silver.

Yours, respectfully,

E. E. BURLINGAME,
A. VON SCHULZ,
Assayers.

G. W. BAKER, *Editor Herald.*

The mill tailings operated upon as above were from Roderick Dhu ore, of low grade milling quality. The yield is reported to have been about three ounces per cord. At seven tons per cord, the result per ton was $8 57. By the above assay, package No. 1, there was left in the tailings $11 01 per ton, gold and silver. If the tailings represented the whole original tons of ore, it would show that the mill saved considerably less than one-half of the precious metals. There are two considerations, however, which prevents such a calculation. The first is, that a portion of the original ore is carried off in suspension in the water. Hence the number of tons of tailings will not equal the number of tons milled. The second consists in the fact that gold is also thus taken off in suspension by the same water. As there are no means of getting at either of these, as to quantity, no actual statement can be made as to what proportion the mill did save of the whole value. Suffice it for our purpose, here is a waste represented by the number of tons of mill tailings worth, in precious metal, $11 per ton.

The test shows an exceeding fineness of stamping or pulverization. The quantity of perfectly atomic particles of metal would most likely cause a loss in water concentration, using the utmost care and best contrivance, of not less than 40 or 50 per cent. of the pyritous matter. The preparation of ores intended to be concentrated does not permit the making of so large amount of fine particles, hence the separation as made by Krom's separator, under these circumstances, is most astonishing, leaving of this exceedingly minute matter only $9\frac{1}{10}$ per cent. of the mass. When we take into consideration the fact that, although this last amount was left, it carried *no gold* whatever, we get at a just appreciation of the value of this experiment. *All the metal containing gold was obtained by the separation.* That which was left in the mass had been so completely comminuted that no gold remained associated with it. This is a fact of extraordinary importance. When it is considered that in concentrating sulphurets of silver by water, under the best conditions, a loss of from 35 to 45 per cent. cannot be prevented, the small amount in value of silver shown by assay of package No. 3 dwindles into insignificance.

The assay of package No. 2, machine headings, shows a larger value in gold and silver than the assay of package of No. 1, mill-tailings, would justify by $2 68. How this originates we cannot say. It requires but a small particle of gold to be present in the one case, or absent in the other, to make a large difference in the result, comparatively. This is all that can be said about such discrepancies. The facts as they are must be taken as the only basis obtainable in such matters.

The results may be summed up—

1st. The Krom machine separated nearly 92 per cent. of the metal from the mass, and left *nothing of value.*

2d. The ore operated upon was in a condition that demanded the most extreme perfection in the machine. The result was most surprisingly successful.

This experiment was tried upon tailings; that is, upon material the very lightest portion of which, together with the finest free gold liable to loss, had been already swept away by water. There seems to have been no test made for quicksilver and amalgam, which would certainly be present, and, by its superior gravity, increase the apparent efficiency of the machine.

With regard to the value of tailings generally, the assays have been made by Messrs. Burlingame and Von Schulz, showing:

	Per ton.
Undressed tailings, 45 samples, average value	$27 86
Blanket washings, 23 samples, average value	59 33
Dressed tailings, 38 samples, average value	42 90

Experiments with Krom's concentrator were subsequently made upon ore of the second-class (mill-rock) with the following results, as published in the Herald:

I.

The lot prepared for separation weighed 3,025 pounds.

First-run headings	996
Second-run headings	225
Tailings	1,804
Total	3,025

ASSAYS.

	Gold.	Silver.	Total.
Before separation	$24 80	$10 40	$35 20
First headings	66 14	17 29	83 43
Second headings	47 12	17 57	64 69
Machine tailings	9 30	4 42	13 72
In 3,000 pounds	37 20	15 60	52 80

CALCULATION.

	Gold.	Silver.	Total.
In 1,200 pounds headings	$38 96	$10 83	$49 79
In 1,800 pounds tailings	8 37	3 97	12 34

II.

Lot of milling stuff, second-class ore, 5,600 pounds.

Headings	767
Tailings	4,833
Total	5,600

ASSAY OF LOT.

Before separation, per ton	$25 37
After separation	
Headings, per ton	98 93
Tailings, per ton	10 99

III.

	Pounds.
Amount operated upon	5,540
Headings	464
Tailings	5,076
Total	5,540

ASSAYS.

	Gold.	Silver.	Total.
Ore, per ton	$10 33	$2 21	$12 54
Headings, per ton	87 22	10 37	97 59
Tailings, per ton	2 48	1 14	3 62

IV.

	Pounds.
Weight of lot treated	6,651
Headings	1,310
Tailings	5,341
Total	6,651

ASSAYS.

	Gold.	Silver.	Total.
Ore, per ton	$42 37	$4 29	$46 66
Headings	150 89	11 59	162 48
Tailings	7 23	1 82	9 05

V.

	Pounds.
Weight of ore	6,210
Headings	768
Tailings	5,442
Total	6,210

ASSAYS.

	Gold.	Silver.	Total.
Of original ore, per ton	$16 53	$2 27	$18 80
Of headings, per ton	99 21	10 92	110 13
Of tailings, per ton	3 10	1 17	4 27

These experiments indicate the usefulness of dry concentration where sufficient water cannot be obtained, or where the necessary capital for complete separating-works is not available. But they do not prove its superiority to the modern apparatus in which water is scientifically employed—an excellent example of which is furnished by the Wilson & Cass works, in Clear Creek County. In the latter works, originally built for dressing argentiferous galena, extraordinary success has been obtained in the concentration of poor gold ores; but the location of the establishment is such as to necessitate expensive transportation of the ore. A serious objection to dry concentration is the requirement of dry-stamping, which is expensive and slow, compared with wet, or of careful drying of the crushed ore, which is also expensive. The subsequent use of the Stetefeldt furnace, recommended by Colonel Baker, is not yet a matter of practical success in treating gold ores; and the royalty charged by the patentees, as well as the great capacity of the furnace, operates somewhat against its introduction. The greatest economy would require the erection of large furnaces, and these could only be supplied with concentrated ore by purchase, there being no single company in Colorado which can keep a Stetefeldt furnace running with its own concentrated ores. In other words, the whole reduction business would pass into the hands of one or two establishments, as is now the case with first-class ores. I doubt both the practicability and the advisability of such a revolution. But the necessity of better concentration and a remodeling of the present system I do not doubt, though I believe that the method of wet-stamping and amalgamation will not be superseded. I should add that in Clear Creek County, where silver ores are treated by dry crushing and chloridizing roasting, Mr. Krom's machine has been for some time in successful operation, without competition. The Central City Register of October 19 gives the following account of recent experiments:

The Washington mill at Georgetown, one of the largest buildings in the place, has had a multiplicity of processes and managers in it at different periods, and as many failures, so that the people learned to look upon it with a superstitious dread when any activity in the way of work was started up, which occurred every year and lasted for about a month; the people would say, "There goes another bubble that will soon burst." This was the case when Krom's dry ore concentrator was put in by Mr. Jacobs in 1869. and, so far as his experiments went, it proved no less a failure than previous processes, Mr. Bement, one of the owners of the property, came to Georgetown last spring for the purpose of determining his future course for his company, in reference to their Colorado investments. He found the machinery in good condition, and determined upon a last effort to make the Krom separator work successfully on the Georgetown ores. He has devoted the entire summer to his experiments, and, with the aid of common sense and close attention to his work, has so far succeeded that the two machines are kept constantly in motion on ore from the Terrible lode, and to all appearance doing the work well. The machinery now in use consists of a Dodge crusher, with Cornish rollers, three revolving screens eight feet long, and three Krom separators, each calculated to work on different-sized particles of ore. Four men do all the work, as follows: One engineer, one in the crushing-room, one tending the concentrators, and one man of all work. The capacity of the mill is eight tons per day of ten hours. Ninety-seven tons of third-class ore have been sent from the Terrible lode to this mill, and thirty-eight tons of concentrated ore have been sent to Stewart's works since they commenced working the concentrators. This third-class ore is dressed down two-thirds, or three tons into one, at a cost of $10 per ton on the gross weight. An actual test gave the following results: Ten and a half tons of third-class Terrible Company's ore yielded 3 tons 860 pounds of concentrated ore; five tons of fourth-class ore yielded by the

same process, 1 ton and 1,216 pounds of concentrated ore. The present working of these machines is not very close. No mineral escapes with the light rock or waste, but a portion of the rock goes with the mineral. This manner of dressing the rock is a success, as will be seen by the following: Stewart charges for reducing this class of ore $35 per ton; three tons, at $35, $105. For dressing three tons into one, at $10, $30; reducing, per ton, $35; total, $65; a saving to the mine-owner on every three tons of third-class ore of $40. So far this process is a success. The fact must not be lost sight of, however, that this method of separation can only be applied to that class of ores in which the silver is carried by the heavier minerals, such as zinc and lead. When the silver exists principally as a sulphuret the process cannot be worked so closely, and happily does not need to, as this class of ore is rich enough without concentration.

SMELTING IN SHAFT FURNACES.

The process of smelting in reverberatories, as employed at Professor Hill's works, is acknowledged to be expensive in fuel and labor, but claimed to be necessitated by the nature of the ores and fluxes. Several attempts have been made to smelt in cupola-furnaces, but most of them have failed, because they required a supply of galena, which could not be obtained. It is a prevalent delusion in Colorado that immense quantities of galena ores can be had by calling for them; but the demand has been repeatedly made in vain. Even the galenas of Clear Creek County are in general so highly charged with zinc-blende, pyrites, etc., as to unfit them for the cupola.

The Western smelting-works, erecting in Black Hawk, at the time of my last visit, under the charge of Mr. William West, a practical smelter, were on a somewhat different plan. The ore was to be desulphurized without crushing, in kilns, such as are used in the manufacture of sulphuric acid from pyrites, then melted in a cupola-furnace, producing a matte, which was to be recalcined and remelted, for concentration. The final separation of the metals was to be effected at the works, sulphuric acid being obtained from chambers to be erected in connection with the kilns. The capacity of the works was intended to be ten tons daily. In this plan, the cupola-smelting is similar to that effected in the copper-furnaces of Ducktown, Tennessee; but the greater proportion of iron-sulphurets in the Central City ores, the different nature of the gangue, and the more serious expense occasioned by short campaigns and "salamanders" render the undertaking more difficult in Colorado. The furnaces were substantially built; and I have since heard of a successful commencement of operations. The experiment is, in my opinion, a hazardous one; but I do not undertake to say it will fail from causes inherent in the metallurgical plan. My latest news, December 3, speaks of the works as running at full capacity.

THE COLORADO COAL.

The most significant single specimen in the fine array of minerals at the Denver Fair was a huge block of coal, said to weigh five and a half tons, from Marshall's mine, near Golden City. Another mine (Murphy's) furnished a single lump weighing two or three tons. The Marshall vein is 14 feet thick, of which 13 feet are workable coal. The question whether this coal can be used in metallurgical operations is an important one, and the answer is, I regret to say, somewhat doubtful. The analysis published of the Marshall specimen (by whom made I do not know) gives but three per cent. of ash and three per cent. of water, the rest being put down as fixed carbon and hydro-carbon. Believing the coal to be lignite, I cannot believe it to be so nearly anhydrous. All lignites contain considerable water in chemical combination; and I fear

that in this analysis the coal was merely dried, and the loss in weight set down as water, while the chemically-combined water, passing off in the subsequent distillation, was reckoned with the hydro-carbon. The error, if such it is, is a vital one. The water in lignites not only decreases the amount of actual fuel, but by evaporation absorbs heat in the furnace; and it may be consequently difficult, or even impossible, to maintain high smelting temperatures with such fuel economically.

Some experiments already made have resulted both ways; but the favorable results, so far as I can learn, were obtained on too small a scale to be perfectly satisfactory, while the unfavorable ones may possibly be due to the employment of the ordinary grates and fire-bridges used for wood, which are, of course, somewhat unsuitable. Decisive tests have yet to be made; meanwhile, I am inclined to believe that the coal can be used successfully in gas-furnaces with regenerators, and perhaps not otherwise. One thing is certain, it is excellent for all domestic purposes, and for the generation of steam; and I hope that it may soon be furnished so cheaply as to supersede wood for these applications. This should make the supply of wood and charcoal for furnaces last much longer than it will at the present rate of consumption. However, it should be added that there is no lack of wood in the Rocky Mountains. The trouble is that it speedily thins out in the neighborhood of towns and metallurgical works; and the prices of labor and hauling are such as to make it expensive when brought from a distance. I hardly think, nevertheless, that the prices of fuel will rise beyond present figures at this place for some time to come. I believe Professor Hill, at Black Hawk, pays from $5 to $7 per cord for wood, and say 13 to 15 cents per bushel for charcoal.

CHAPTER XII.

THE SPEED OF STAMPS IN COLORADO AND ELSEWHERE.

The question, what is the best proportion among weight, fall, and speed of stamps, is one which has not yet received thorough and systematic examination. In considering the economical application of stamping-machinery, we meet, at the beginning, with serious difficulties in obtaining accurate data for comparison. The weight and fall of stamps vary as the shoes and dies wear out; and this may lead to a change of speed also. Moreover, defects in engines, boilers, or machinery for the transmission of power, may occasion serious losses, which cannot fairly be charged to the arrangements of the stamps proper. Again, the capacity of stamp-mills is directly dependent, in some degree, upon the nature and extent of discharge, fineness of screens, and other peculiarities of the battery. Finally, the hardness and tenacity of the rock crushed varies so much that comparisons between different localities cannot be implicitly trusted. The safest experiments are those made in the same mill, by changing first one and then another condition of working; but this is seldom possible for such conditions as weight and lift of stamps, and only within narrow limits for their speed.

We may eliminate questions of friction, transmission, and generation of power, in the case of stamps, by measuring the power actually developed by their fall. Thus, the weight, multiplied into the fall in feet, and the number of drops per minute, gives us exactly the number of foot-pounds exerted by each stamp. Dividing by 33,000, the number of foot-pounds per minute in one-horse power, we have the horse-power per stamp, from which the effective power of the whole mill may be obtained. Dividing the amount of rock crushed daily by the effective horse-power, gives us the daily amount per horse-power; and this is the best measure that can be obtained for the effectiveness of the stamps. A complete discussion of the subject would require us to determine the exact influence of the discharge, etc., and the exact resistance offered by different classes of rocks, for both of which points the data are wanting.

Professor J. D. Hague, in the third volume of the United States Geological Exploration of the Fortieth Parallel, gives a valuable table of the operations of a number of mills in Gilpin County, Colorado. The discussion of this table leads to some interesting results, which I shall briefly set forth. I give a portion of it, rearranged to suit the object in view, and furnished with additional columns.

Relative efficiency of certain stamp-mills in Gilpin County, Colorado.

Number.	Name.	Number of stamps running.	Weight of stamps in pounds.	Fall in inches.	Drops per minute.	Total horse-power developed.	Total tons of ore crushed daily.	Tons daily, per horse-power, developed.
1	Hurd's	20	660	14	30*	14.0	17	1.21
2	Black Hawk	60	850	14	15	27.0	30	1.11
3	Polar Star	24	425	14	30	10.8	15	1.38
4	Chicago	20	450	14	40	13.5	15	1.11
5	Nesmith	20	550	14	35	13.2	17½*	1.32
6	University	15	500	15	30	8.1	11½*	1.41
7	Holbrook's	13	500	14	30	6.6	11½*	1.73
8	Miley & Abbe's	25	584	12	28	12.4	26	2.10
9	Sensenderfer	20	450	12	34	9.2	15	1.62
10	Holman	12	400	12	22	3.2	7½	2.34
11	Bates	8	425	12	30	3.1	7½	2.43
12	Smith & Parmelee	25	550	14	35	17.0	22½	1.32
13	Gregory No. 1	20	850	14	16*	9.6	13	1.35
14	Star	12	500	12*	40	7.3	7½	1.03
15	Narragansett	40	750	14	30	31.8	37½	1.18
16	Montana	30	750	12	40	27.2	33¾*	1.24
17	Pacific National	24	600	12*	35	15.3	22½	1.47
18	Gilpin Company	18	500	16	32*	11.6	11½*	0.98
19	First National	25	900	14	28	22.3	22½	1.01
20	Ophir	24	500	14	30	12.7	18¾	1.47
21	Whitcomb's	12	430	13	32	5.4	11½*	2.12
22	Quartz Hill	12	550	16	22	5.9	7	1.19
23	Blue	12	700	8	40	6.8	12½*	1.84
24	Carondelet	12	350	12	50	6.4	21	3.30
25	Gleason & Company	8	650	15	27	5.3	7	1.31
26	Miley & Johnson	16	500	12	40	9.7	19*	1.96
27	Delaware	15	500	12	26*	5.9	13	2.20
28	Perrin	10 12	450 600	12* 13	45* 23*	11.6	16½*	1.42
29	Lincoln	12	625	14	24	6.4	12½*	1.96
30	Beloit	12	450	16	28*	6.1	6½*	1.08
31	Trust	30	700	14	25*	18.6	20½*	1.10
32	Winnebago	20	500	15	30	11.3	15	1.32
33	Eureka	18	450	15	25	7.7	12	1.55
	Totals	656	396,110	....	....	383.0	537	51.16
	Numerical averages	19.88	603.83	15.34	29.69	0.58	0.82	1.55
	Dynamical averages	19.88	603.83	13.53	28.31	0.58	0.82	1.40
	Gross averages	19.88	580.27	13.41	30.82	11.60	16.27	1.55

I have taken from the report the names of mills, number of stamps running, weight of stamps, fall in inches, number of drops per minute, and tons of ore crushed per day. To these columns I have added one giving the total horse-power developed and one giving the tons of ore crushed daily per horse-power developed. These figures are obtained by separate calculations for each mill. At the bottom of the table certain totals and averages have been added. The total number of stamps explains itself. The total weight is arrived at by multiplying the number and weight for each mill, and then aggregating these products. The total horse-power, again, is a simple addition. The methods of obtaining averages require more detailed comment. In several columns the numerical differs decidedly from the dynamical average; thus, if we multiply the number of stamps in each mill by their fall, add these products, and divide the sum by the total number of stamps, we obtain a numerical average of the fall; and a similar process gives us a numerical average of the number of drops per minute; but if we should attempt to deduce from the total number of stamps, their average weight and (numerical) average fall and speed, the total horse-power developed, we should obtain a result different from that which is arrived at by simply

* Estimated, generally from maxima and minima given. Thus 15 to 20 is put at 17½.

adding the totals given in the column of horse-power developed. The reason is obvious. In taking a merely numerical average we leave out of account the weight of the different stamps; it is therefore necessary to multiply the number *and weight* of stamps of each mill into the drop and to divide the sum of these products by the aggregate weight of all the stamps of all the mills. In calculating the average speed the drop, as well as the number and weight, must be included. This can be best illustrated by an example, comprising, for the sake of simplicity, only two mills. I take, almost at random, Nos. 2 and 11 from the table, viz:

Black Hawk: 60 stamps, 850 pounds, 14 inches, 15 drops, 27 horse-power.

Bates: 8 stamps, 425 pounds, 12 inches, 30 drops, 3.1 horse-power.

The totals would be 68 stamps, 54,400 pounds, and 30.1 horse-power.

The numerical averages are obtained as follows:

Fall.—$60 \times 14 = 840$
$8 \times 12 = 96$

68 — 936 Average fall, 13.76 inches.

Speed.—$60 \times 15 = 900$
$8 \times 30 = 240$

68 — 1,140 Average speed, 16.76 drops per minute.

But these averages would give us $54{,}400 \times \frac{13.76}{12} \times 16.76 \div 33{,}000 =$ 31.68 horse-power, whereas the aggregate horse-power, as we know by calculating it separately for each mill, is 30.1 horse-power.

The dynamical averages, on the other hand, are obtained as follows:

Fall.—$60 \times 850 = 51{,}000$ — $51{,}000 \times 14 = 714{,}000$
$8 \times 425 = 3{,}400$ — $3{,}400 \times 12 = 40{,}800$

54,400 — 754,800

Average fall $= 754{,}800 \div 54{,}400 = 13.87$ inches.

Speed.—$714{,}000 \times 15 = 10{,}710{,}000$
$40{,}800 \times 30 = 1{,}224{,}000$

754,800 — 11,934,000

Average speed$=11{,}934{,}000 \div 754{,}800 = 15.81$ drops per minute.

If now we calculate the total horse-power upon these dynamical averages, we have $54{,}400 \times \frac{13.87}{12} \times 15.81 \div 33{,}000 = 30.1$ horse-power, which agrees with the total from the table.

A third set of averages, which I call, for convenience, gross averages, is obtained by disregarding the number as well as the weight of stamps, and considering only the number of mills. Thus, in the case just given, the gross averages would be 637.5 pounds, 13 inches, and 22.5 drops. This has little value for accuracy; but it is the usual manner in which casual observers estimate the matter, and it shows what is the fashion or prevailing custom among owners of mills. Bearing these distinctions in mind, we have the following results, based on a comparison of thirty-three mills:

Total number of stamps, 656; average number in each mill, 19.88; total weight of stamps, 396,110 pounds; average weight, 603.83 pounds; average weight reckoned by mills, without reference to their size, 580.27

pounds; average fall in inches, reckoned from the number of stamps only, 15.34; average fall in inches, reckoned from the number of mills only, 13.41; average fall in inches, reckoned from number and weight of stamps, or average fall of the average stamp of 603.83 pounds, 13.53; average speed by stamps, 29.69 drops per minute; average speed by mills, 30.82 drops per minute; average speed of the average 603.83-pound stamp, falling 13.53 inches, 28.31 drops per minute; total horse-power developed, 383; average per stamp, (obtained by dividing by the total number of stamps,) .58; horse-power developed by the average stamp at average fall and speed, (calculated from the dynamical averages,) .58, which necessarily agrees with the foregoing; average per mill, 11.60 horse-power; total number of tons crushed daily, 537; average per stamp, .82; average per mill, 16.27; total number of tons crushed by the development of thirty-three horse-powers, one in each mill, 51.16; average per mill or stamp, numerically, 1.55; actual daily product per horse-power developed by the average stamp, 1.40 tons. These figures admit of further profitable discussion.

The difference between the gross and dynamical averages of weight of stamps indicates that the larger mills carry, on the whole, heavier stamps. The difference between the gross and dynamical averages of fall is slight, while both of these are considerably less than the numerical average, showing that the larger mills, on the whole, adopt a greater fall than the gross average, but the greater aggregate weight of metal in the smaller mills nearly restores the dynamical average to the prevailing fashion, as shown by the gross average. The differences in the averages of speed are more difficult to explain. It appears that 30.82 drops per minute is the fashion, and that the few large mills running at 15 and 16 do not reduce the numerical average below 29.69. But when the fall is taken into consideration, it appears that the slow-running stamps (as might be expected) drop further, thus increasing their effect, and reducing the real effective average speed to 28.31 drops per minute. The difference between the dynamical and numerical averages of daily product per horse-power shows that the mills developing less than 11.6 horse-power crush, on the whole, slightly more in proportion than those of greater capacity; but in view of the very great variations in the final column of the table, this residual difference is comparatively insignificant, and it may be assumed that deficiencies in economy are pretty equally divided between the two classes. If the matter turned upon the daily management only, the larger mills being presumably under more skillful management, might be called upon to show better results; but the conditions here discussed are mainly those of original construction; and some of the largest mills in this table are among the oldest and the worst.

How far is this exhibit invalidated by the conditions of discharge, size of screens, etc., and hardness of rock, not included in it? By the former, I think, not to any great extent, as it may safely be assumed that these conditions have been made as favorable in every case as the form of the battery and the necessities of amalgamation will allow, and, moreover, that the mortars and screens are of one general pattern, the California high mortar not being in favor, and Russia iron, punched, being preferred to wire screens, and slits to needle-holes. Variations in the diameter of shoes are, I must confess, more common, and constitute an element which I have disregarded only because the data are wanting. But this element, if included in the discussion, would strengthen the conclusions arrived at, since the mills having the largest diameter of shoe, as the Black Hawk and Gregory, which have 9-inch

shoes, do not reach on that account even the average efficiency. It may be inferred, therefore, that in crushing average quartz the conditions of weight and speed are more influential than slight variations in the crushing surface.

The hardness of rock is a serious disturbance to the calculations. Surface rock differs considerably from the deep quartz in this respect, and doubtless affects unfavorably the apparent results of the larger mills. It should be distinctly understood, therefore, that the general conclusions deduced from the table at the beginning of this chapter are modified by special conditions. If any mill shows a considerable departure from the average effectiveness, it is fair to inquire what kind of rock it is crushing before concluding that its superior or inferior capacity is due to the weight, drop, and speed of the stamps.

With these qualifications, we may assume that the average or normal stamp of Colorado weighs about 600 pounds, drops about 13.5 inches, about 28 times a minute, and crushes 82 tons daily, or about 1.4 tons per horse-power developed. This is probably less than the average efficiency, measured in the same way, of California stamps. It is, indeed, somewhat in excess of the estimate of Mr. Ashburner, whose observations some five years ago led him to fix upon 1.25 tons daily per horse-power, as the average result of the stamp-mills of California, but improvement of construction since introduced have increased their capacity.

The mill at Lone Pine, Inyo County, (p. 22 of my last report,) is said to crush per horse-power, daily, 3.81 tons, with 650-pound stamps, dropping 8 inches, 60 times per minute.

The table of quartz mills in Tuolumne County, California, (*Ib.*, p. 26,) gives the following results when reduced:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Clio	500	60	8	1.65
Eagle	500	80	6	1.48
Golden Rule	750	70	6	1.26
Knox & Co	500	65	6	1.62
App	600	80	6	2.20
Heslep	500	60	7	1.51
Trio	400	60	8	1.24
Mooney & Co	800	40	10	2.06
Oliver & Harris	600	65	9	1.13
Reist	500	55	8	2.16
Rawhide	600	70	8	1.47
Patterson	500	60	8	1.24
Musser	500	60	8	1.65
Soulsby	500	60	10	1.24
Starr King	500	60	8	1.65
Gilson	500	60	8	1.65
Grizzly	500	60	8	1.65
Bonita	500	60	8	1.65
Consuelo	500	60	8	1.65
Monitor	500	60	8	1.65
Hazle Dell	500	60	8	1.65
Shanghai	500	60	8	1.65
Hunter	500	60	8	1.65
Sell & Martin	500	60	8	1.37
Nonpariel	500	60	8	1.65
Burns & Co	500	60	8	1.65
Rattlesnake	500	60	8	1.65

The stamp-mills of Sutter Creek mining district, in Amador County, California, (*Ib.*, p. 34,) show, by a similar calculation, the following results:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Eureka	650	76	9	1.67
Badger	500	79	9*	1.18
Rose	500	75*	9*	1.46
Lincoln Mill	450	79	9	1.48
Mahony Brothers	600	70	11	1.14
Mahony	600	70	11	1.07
Keystone	600	74	9	1.59

The table of quartz mills in Eldorado County, California, (*Ib.*, p. 37,) yields, under discussion, the following results:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Pacific	500	75	8	1.32
Harmon	300	75	8	1.76
Reed	600	75	10	1.32
Independence	665	80	9	1.24
Crystal	650	70	9	1.45
Stillwagon	400	65	9	1.65
Star	400	80	9	1.72
Confidence	300	80	7	3.93

The quartz mills of Colfax district, Placer County, (*Ib.*, pp. 39, 42,) show:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Live Oak	600	60	12	1.83
Rising Sun	800	65	11	1.38
Green Emigrant	700	75	10	1.51
Pioneer	800	60	10	1.24

Some of the quartz mills of Nevada County, California, show the following results, (see report of 1870, pp. 44, 200; and report of 1869, pp 23, 26, 27, 29:)

* Estimated.

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Eureka	700	10†	68	1.66
	850	10†	60	1.70
Empire*	800	10†	62	1.06
North Star	950	10†	60†	1.30
Idaho	950	10	60	1.62
Pittsburg	650	10†	82	1.63
Allison Ranch	1,000	11	60†	2.00

* Destroyed by fire in 1870. † Estimated.

Four mills in Sierra County, California, (see report of 1870, p. 68,) show the following:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Brush Creek	700	62	8¼	1.29
Independence	700	60	8	.89
Alaska	700	60	8¼	.99
Docile	750	85	7¼	1.41

Some of the quartz mills of Yuba County, California, (*Ib.*, p. 71,) give:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Pennsylvania Mill	650	70	10	1.30
Donnebroge Mill	720	70	10	1.18
Rattlesnake Mill	650	70	10	1.30
Sweet Vengeance Mill	650	70	10	1.30
Scabby Hill Mill	600	70	10	1.41

The quartz mills of Oregon gulch, Butte County, California, (*Ib.*, p. 74,) give:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches	Tons daily per horse-power.
Nisbet Mill	600	68	10	1.45
Cambria Mill	600	68	10	1.45
Sparks & Smith Mill	750	68	10	1.16

The quartz mills of Plumas County, California, (*Ib.*, pp. 76, 78,) show the following relative efficiencies:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Eureka	750	65	9	1.45
Mammoth	750	60	8	1.83
Woodward & Co.	500	60	10	1.76
Bull Frog	750	60	8	2.20
Crescent	850	70	10	1.35
Judkins & Kellogg	750	65	8	2.03
Caledonia	750	65	8	2.03
Dixie	400	60	7	2.94
Batchelder's	400	45	7	4.71*
Lone Star	600	50	7	2.83
McClelland	400	35	7	4.66*
New York	600	60	9	2.44
Pennsylvania	750	60	8	2.20
Indian Valley	600	60	9	2.44
Whitney	750	65	11	1.55

* These figures are so large that they should be rejected as involving either an error in the report, or some unexplained peculiarity of conditions of operation.

The quartz mills of Shasta County, California, (*Ib.*, p. 85,) show the following calculated efficiency:

Name of mill.	Weight of stamp.	Number of drops per minute.	Height of drop in inches.	Tons daily per horse-power.
Washington Mill	600	60	6	1.83
Highland Mill	500	60	6	2.20
Honeycomb Mill	600	60	6	1.83
Potosi Mill	600	60	6	1.83
Mammoth Mill	600	60	6	1.83
Jollie Mill	300	60	6	2.75
Peck's Mill	500	60	6	2.20

The Hermit Mill, in the Sweetwater district, Wyoming, (*Ib.*, p. 331,) shows the following: Weight, 650; speed, 80; drop, 8½; tons daily per horse-power, 1.79.

An interesting comparison may be made with the stamp-mills of Australia and Brazil. (*Ib.*, pp. 677–'79.) The rough averages given for the different Australian districts cannot be very closely discussed; but by taking the arithmetical means of the maxima and minima of horse-power and product given, we have:

District.	Weight of stamp.	Height of drop in inches.	Number of drops per minute.	Horse power expended per stamp.	Tons daily per horse-power.
Ballarat	400 to 850	7 to 10	50 to 85	1.00 to 2.00	1.66
Beechworth	442 to 775	5 to 14	40 to 90	.75 to 1.50	2.13
Sandhurst	500 to 800	6 to 18	25 to 75	.66 to 2.00	1.50
Maryborough	450 to 800	6 to 22	50 to 75	.50 to 2.50	1.33
Castlemaine	450 to 800	6 to 15	35 to 75	.50 to 2.00	1.70
Ararat	500 to 675	7½ to 10	60 to 72	.75	1.83
Gipp's Land	600 to 750	7 to 10	60 to 80	.75 to 1.50	1.58

The stamp-batteries of the Port Philip Company, at Clunes, Australia, show, (*Ib.*, p. 678:)

Weight of stamp.	Drop. in.	Speed.	Tons daily per H. P.
600	8*	75	2.42
800	8*	75	3.30

This is extraordinary efficiency; but the batteries are aided by rock-breakers, *and have a double discharge.*

The stamp-mills of Cornish pattern in use at the Morro Velho mines, Brazil, (*Ib.*, p. 679,) show:

Name of stamp-mills.	Weight of stamp.	Blows per minute.	Lift of stamp-heads in inches.	Tons daily per horse power.
Lyon	640	63	10	1.19
Cotesworth	640	61	11	1.30
Susannah	640	65	12	95
Herring	640	78	12	95
Powles	640	67	12	1.41
Addison	640	73	12	1.05

Comparing the stamp-mills of Colorado with all these examples from other regions, we notice that the speed of their stamps is, on the average, much less, and that, to say the least, the efficiency is no greater than that of more rapid running. But the argument for a higher speed is fairer if the Colorado mills are compared among themselves. Returning, therefore, to the table given on page 381, we notice that of eleven mills exhibiting a greater efficiency than the average of 1.55, five are run at a speed exceeding the average of 30.82, two at 30, and the remaining four at 22, 24, 26, and 28, respectively. The highest efficiency is attained by the Carondelet mill, having the lightest stamps, (350 pounds,) run at the highest speed, (50 drops per minute,) and crushing daily 3.30 tons per horse-power. The Blue mill, on the other hand, develops nearly the same horse-power, but crushes only little over half as much. In the latter case, twice the weight of metal is dropped two-thirds as far, four-fifths as often; and while the power is nearly the same, this different application of it appears to be far less advantageous.

On the other hand, there are instances in the table which seem to contradict such a conclusion. The slow rate of running insures an immediate and adequate discharge; and much of the advantage of a rapid

* Estimated.

rate is lost when the discharge is not ample. The remarkable increase in product secured by the use of a double or even a continuous discharge around the whole battery-box would doubtless influence mill-men to adopt this improvement, were it not for certain difficulties, partly real, partly imaginary, in its use.

If we consider economy as well as efficiency in crushing, the advantage of a high rate is evident. With the same machinery, wages, etc., and, if the mill is well built, with little or no extra repairs, a large increase in capacity is secured. Moreover, the first cost may be reduced by the use of lighter batteries. Probably, also, the increased speed may be attained with less than the proportional increase of fuel.

The objections to higher speeds in Colorado mills are partly set forth in my last report, (pages 365–'66,) in the words of a writer in the Central City Register. His argument is, substantially, that experience has shown different rates of speed to be best for different kinds of ores. Instances are given in which, upon an increase of speed, the yield of gold per ton fell off; and it is claimed that this test should decide what rate is to be adopted in each case. In other words, the rapid running of the stamps, and consequent augmentation of product crushed, causes greater agitation within the battery-box, and requires a larger supply of water to clear the discharge and carry away the greater amount of pulp. The excess of agitation in the battery may prevent the accumulation of gold on the interior plates, and the excess of current on the aprons may prevent the accumulation of gold there. These objections are most plausible when the gold is most finely divided in the quartz. I propose to consider them briefly.

This reasoning amounts to the confession that the conditions most favorable to economical crushing must be partly sacrificed to secure efficient amalgamation. Is this sacrifice really necessary, or is it merely involved in the method of amalgamation adopted in the Colorado mills? The attempt to catch the greater part of the gold on the interior plates interferes directly with the greatest efficiency of the stamps. The success of the amalgamation at this point is in inverse proportion to the success of the crushing and discharge. There is a certain advantage gained in the force with which the pulp is dashed against the plates; but this force is liable to overdo, and thus undo, its own work, and actually remove the adhering amalgam. The same effect can be more completely secured outside of the battery.

But the arrangements outside are generally poorly adapted for the purpose. The pulp is swept over a small, steep, and smooth amalgamated surface; and it is no wonder that so little gold is caught upon the aprons. The Port Philip, Australia, mills, (see my report of 1870, p. 678) have five distinct steps or drops in the outer plates, where the Colorado mills have none. If this arrangement were adopted, an excess of water would occasion no loss, and the efficiency of amalgamation would be increased.

The principal objection appears to be the clogging of the outside riffles or steps with pulp, or the removal of amalgam by the falling of the pulp over the steps. But it strikes me that if Australian mills can overcome these difficulties we ought to be able to do the same.

Even retaining the present patterns of outside aprons, the effect of a greater amount of water could be neutralized by spreading the discharge over a wider surface. Let us suppose, for instance, that a twenty-stamp mill is run at a low speed, for fear of losing gold if more quartz and more water were passed through it in a given time; and that ten of the stamps, run at a high speed, would have the same crushing capacity as

the whole mill at present. Why not run ten stamps in this way, and discharge upon the apron surface of the whole twenty? After the pulp is once through the screens, and sliding over the apron, it makes no difference how fast it was crushed. In a word, the conditions of amalgamation should be, and can be, regulated without interfering with the conditions of pulverization. Loss of gold should be, and can be, prevented without crippling the efficiency of the stamps. Power, space, and time are at our disposal; and by a proper use of the two latter we may avoid wasting the first, which is the most costly.

My views on this subject may be summed up as follows:

1. The stamp-mill is the most convenient and practically efficient machine for crushing quartz thus far introduced and proved by experience. It involves little waste of power in gearing; it delivers its power in the most direct and practical manner, namely, by blows, which take advantage of the brittleness of the rock, instead of pressure or friction, which invite the resistance of hardness; its capacities for charging and discharging are ample and easily regulated, both as to quantity and as to fineness of the product; it is subject to few and comparatively inexpensive repairs, and it can be repaired, in most cases, without complete stoppage. These and other excellent features in its construction and operation render it especially suitable for use in mining districts remote from machine-shops, founderies, and centers of skilled labor.

2. To obtain the best results, stamp-batteries should be built and run to secure the highest efficiency and economy in crushing only, without reference to amalgamation. The amalgamating apparatus should be adapted to the batteries, not the latter to the former. If interior plates are employed, they should not be expected to catch the greater part of the gold, nor should the pulp escaping through the screens be swiftly and carelessly manipulated, when a little extra space and time devoted to it, almost without extra labor, would avoid much loss.

3. The efficiency of a stamp may be described as the product of three factors—weight, fall, and speed. The efficiency of a battery of stamps involves a coefficient—the discharge.

4. When the fineness of crushing is regulated by screens, the discharge should be as large as practicable. There may be mechanical objections to continuous screens running around the whole battery; but there are, I think, no valid arguments against the double discharge, in front and rear, when the battery is properly planned with reference to it. Of course a feature of this kind cannot always be successfully added, like a patch, to a battery not duly proportioned for it.

5. Of the three factors of the efficiency of the stamp, the weight and fall determine the force of the blows, and the speed determines their frequency. The height of fall is practically limited by the speed, and by considerations of mechanical convenience.

6. Within certain limits, light blows, frequently repeated, are more efficient than heavy blows at longer intervals. These limits are the following: The stamp must be heavy enough to work steadily, and fall far enough to allow proper feeding and distribution of the ore, and to produce the splash necessary for effective discharge. (In many cases, by the way, more weight might be advantageously put in the stems, and less in the heads.) Again, the blow must be heavy enough to crush the rock upon which it falls. If too heavy, it may waste power in packing the crushed rock; if too light, it may fail to crush, and so may pack. Finally, the speed should not be so great as to prevent proper clearance, or the stamp may strike a second blow upon the rock already crushed.

7. The efficiency of a blow from a heavy stamp with short drop is less

than that of an equal blow (in foot-pounds) given by a lighter stamp with longer drop—the practical limits already referred to being observed—because the longer drop gives greater final velocity to the stamp, and this tends to crush more and to pack less. The same principle underlies the effect of nitro-glycerine, as observed at the bottom of blasting-holes, where the rock in the immediate neighborhood is shattered and pulverized by the suddenness of the explosive shock.

8. The superior effectiveness of frequent blows lies in the fact that there is a limit to the amount of crushing which can be practically performed by a single impact upon a given quantity of rock distributed over a given surface. Thus, a thousand foot-pounds, delivered instantaneously upon a surface eight inches in diameter, may be resolved into six hundred of minute motion or crushing, and four hundred of gross motion, or packing, and heat; while five hundred foot-pounds, under the same circumstances, may perform four hundred of crushing, and waste only one hundred. Two of the latter blows would then effect more with the same force than one of the former. There is another practical advantage of high speed. If stamps are left, as it were, standing in the pulp, between blows, the material settles around them and they "suck" when the lift commences. A great deal of power is frequently wasted in this way, by not picking up the stamps before they become partially buried.

9. But even if the efficiency of stamps were always exactly measured by the product of the three factors mentioned, that is, by the number of foot-pounds delivered per minute, (which is certainly not the case,) there would still be good reason for preferring rapid running. After the necessary stability and strength are secured, increased weight of machinery is an evil. If equal results can be achieved by substituting speed for weight, the change is advisable.

10. In the case of the Colorado mills, the argument is still stronger. Their (gross) average weight of stamp, 580 pounds, is not excessive; their average drop, 13½ inches, is not too large to admit of high speed; but their average speed, say 30 drops per minute, is extremely low, and might be doubled with advantage. A bad arrangement for amalgamation is one excuse, which should be removed, not pleaded. Another serious objection, which Colorado experts are not so free in expressing, is a bad construction of battery foundations and frames. It is feared that high rates of speed would rack or upset the batteries. The difference in this respect between the mills of Colorado and those of other regions may be seen by comparing the drawings given in a previous chapter of this report with that on page 664 of my former report. The California mortar rests on a vertical block, and the blow of the stamp does not communicate vibrations to horizontal timbers.

I believe the views I have expressed are coming more and more to be those of American millmen, even in Colorado. The true evidence of this tendency is to be found in the patterns of the new mills, rather than the practice of those persons who are frequently obliged to adapt themselves to the proportions or condition of antiquated machinery. Moreover, the manufacturers frequently adhere to the old patterns, or at least put higher prices upon machinery constructed after new ones; and few engineers have the opportunity of dictating from their own experience the details of their mills. Mine-owners think a stamp is a stamp, and a steam-engine a steam-engine; and desiring so many stamps with so much horse-power to run them, pick up what they want wherever they can get it most cheaply—at second-hand, if possible. But many causes, and particularly the keen competition among custom-mills, are bringing about a wholesome progress in this matter.

CHAPTER XIII.

THE WASHOE PAN AMALGAMATION.

The third volume of the Report of the United States Geological Exploration of the Fortieth Parallel contains an admirable chapter, from the pen of Professor J. D. Hague, on the treatment of the Comstock ores. As the expensive character of that work, and the comparatively limited edition of it published by the Government, prevent its general circulation among the classes most interested in this part of its contents, a portion of the chapter referred to will be here abridged, with such notes and comments as may seem useful.

The division of the Comstock ores into first, second, and third class is arbitrary and variable, having reference rather to the treatment chosen for each class than to the mineralogical constitution of the ore. The first class receives the most careful treatment, and usually possesses an assay value exceeding \$150, or even \$100, per ton. The second class, where it is distinguished at all, usually includes ores assaying from \$90 to \$150. The third class comprises all workable ore of still lower grades.

The first-class ores form but a small proportion of the whole. For instance, the Savage mine produced, in the year ending July 1, 1868, 87,341 tons of ore, yielding an average of \$40 84 per ton, of which only 277½ tons were first class, having an average assay value of \$449 40 per ton, and an average yield of \$359 52; and 4,745 tons were second class, with an average assay value of \$124 25 to \$142 82, and yielding \$78 16 per ton. The remaining 78,432½ tons of third-class ore assayed \$52 01 to \$55 11, and yielded an average of \$37 20. In the following year, out of a total of 69,287 tons, there were only 68¼ tons called first class, and having an average assay value of \$275 47, while there was no second class distinguished, and 55,411 tons of the third class, assaying \$50 78 to \$60 29, yielded \$34 64 per ton.*

About 25 to 30 per cent. of the value of these ores is gold, and the remainder silver. In the bullion produced the relative proportion of the gold is a little higher,† as it is more completely saved than the silver.

The first-class ores are treated with dry crushing, roasting with salt, and subsequent amalgamation. The ores of the second and third classes are subjected to the "Washoe" process proper, as follows:

Crushing.—This is universally performed in stamp-mills, the larger pieces being "spalled" to a suitable size for feeding into the batteries. For this purpose Blake's rock-breaker is frequently used instead of the hand-sledge.

The foundation of the battery is like that adopted in California,‡ consisting of heavy vertical timbers, firmly bolted together, and tightly packed with clay or earth. The mortars are usually placed directly upon these vertical mortar-blocks. The mortar in general use for wet-

* The earlier operations of the Comstock furnished a much larger proportion of rich ores, partly because the rich ores were eagerly extracted, and those of lower grade left standing. The greater part of the product of late years has been from material overlooked or discarded by the extravagant managers of the "flush times" of Washoe. It would be unfair to argue from the figures that the vein has to this extent "grown poorer;" they rather show that the operations of extraction and reduction have become cheaper, more skillful, and more rational.—R. W. R.

† Generally assumed, roughly, at one-third the value.—R. W. R.

‡ Differing from the Colorado plan, as will be seen by reference to the chapter on that subject in this report.—R. W. R.

crushing is an iron box or trough, 4 or 5 feet in length and depth, and 12 inches in inside width, cast solid. The feed-slit is 3 or 4 inches wide, and the discharge-opening is 12 to 18 inches high, the lower edge being 2 or 3 inches above the top of the die. The single discharge is generally used. The screens are of brass wire-cloth, 40 to 60 meshes to the inch, or (as is preferred for wet-crushing) of Russia sheet iron, perforated with holes $\frac{1}{40}$ to $\frac{1}{24}$-inch in diameter. The dies are cylindrical, 4 to 6 inches high, and usually cast on a square flat base, with truncated corners, so as to fill the bottom of the mortar, and yet be easily removed when necessary.

The stamp-stems are usually of turned wrought iron, about 3 inches in diameter, 10 to 12 feet long, and slightly tapered below to fit the sockets in the heads. The latter are cylinders of tough cast iron, about 8 inches in diameter and 15 inches high. The socket for the stem is about 7 inches deep. A similar, but larger, socket in the lower end of the head receives the shank of the shoe. Each end of the stamp-head is encircled with a stout wrought-iron hoop, shrunk upon it like a tire.

The shoes are usually about 8 inches in diameter and 6 inches high, with a tapering shank about 5 inches high and 4 to 5 inches thick where it joins the shoe proper. They are made of the hardest white iron,* and are replaced when worn down to about one inch in height.

The collar or tappet, preferred in California and Nevada, is Wheeler's gib-tappet, which is cylindrical in form, (effecting the revolution of the stem during the lift,) and differs from others of that pattern in the manner of its attachment to the stem. This is effected, not by tapering the stem or cutting the screw-thread or key-seat upon it, but by means of a gib and two keys, which clamp the collar to the stem at any desired point.

The rotary motion of the stamp, imparted by the friction of the cam against the tappet, is in very general use in Nevada. This is one of the advantages offered by the use of round shoes, stems, and tappets. The revolving cam, meeting the tappet and raising the stamp, causes it, while being lifted, to make a partial revolution about its vertical axis, which rotary motion being continued during the free fall of the stamp, produces a grinding effect between the shoe and die upon the substance to be crushed. Not only is the effective duty of the stamp at each blow increased in this way, but the shoe wears down much more evenly than when it falls without such rotary motion.†

The guides, which are of wood, and supported by the cross-timbers of the battery-frame, are placed, one set below the tappet, about a foot above the top of the mortar, and the other set near the top of the stem, so that six inches or a foot of the latter may project above.

---

* The manner in which shoes, heads, and stems are attached together in practice is described in the chapter on the Colorado process in this report.—R. W. R.

† I have copied this paragraph *verbatim* from Professor Hague's chapter; but I must take leave to doubt the existence of an effective grinding action, such as he describes, at least from stamps run at ordinary speed, say 30 to 70 drops per minute. The circular revolving stamps have their advantages, no doubt; the chief ones being convenience and regularity of wear. But their dynamic advantage, if it exists at all, is much overrated, as the statistics of *the best* square stamps will show. If I remember correctly, some comparative tests, made under the superintendence of Mr. S. S. Robinson, in one of the largest stamp-mills of the Lake Superior copper region, did not indicate a greater crushing capacity for the revolving stamps. And it may well be questioned whether the most recent German batteries (which still retain the square stamp) are not as effective as our own.—R. W. R.

The cams are of tough cast iron, and usually double-armed.* The proper curve of the face is the involute of a circle, the radius of which is equal to the distance between the center of the cam-shaft and the center of the stamp-stem. This form keeps the bottom of the tappet constantly perpendicular to the radius of the cam-curve, and thus lifts the stamp vertically and uniformly. The involute is described in practice by cutting from a thin board a circular piece, the radius of which is equal to the horizontal distance between the centers of shaft and stem, as above. At a given point on the periphery is fixed one end of a thread, having the length of the greatest desired lift of the stamp, and to the other end of the thread is attached a pencil-point. The circular piece, with the attached thread wound on its periphery, is laid on a smooth board, on which the involute is to be traced, and the thread, being constantly stretched "taut," is unwound until it forms a tangent to the circle at the point where the other end is attached. The line described by the pencil-point is the desired curve. This is frequently modified somewhat, receiving a greater curvature at each end, to diminish the shock of catching the stamp and the wear upon the tip of the cam in letting it fall again.

The face of the cam is 2 to 2½ inches wide. It is placed as near the stamp-stem as is possible without contact. The cams are keyed or wedged to the iron cam-shaft, which varies in diameter from 4 to 6 or 7 inches, according to its work. In some mills a single cam-shaft drives all the batteries; but short shafts, one for each battery or pair of batteries, are preferred, as permitting stoppage of part of the mill without interfering with the rest.†

A common order of fall in the usual five-stamp battery is 3, 5, 2, 4, 1.‡ The weight of stamps in most general use is between 600 and 700 pounds. They are usually run at about 70 or 80, sometimes 90 or even 100, blows per minute. They drop from 7 to 10 inches, according to their speed, the greater number of blows per minute requiring shorter lift. In wet-crushing on Comstock quartz, and discharging through No. 5 or No. 6 screen, the average duty is about two tons in twenty-four hours.§ In some mills it is said to reach three tons.

Feeding is usually performed by hand, but in some mills automatic feeders are employed, which give satisfaction. The arrangement comprises a hopper filled with ore,‖ and a chute, leading to the feed-slit of the battery, so inclined that when agitated it will cause the ore to slide down. The chute is hung on a pivot, and a rod is attached in such a manner that the tappet will strike upon it when the stamp falls so far as to require a fresh supply of rock. The shock agitates the chute and causes the ore to move down and fall into the battery.

The consumption of water is usually between 250 and 300 cubic feet per ton of rock treated, or from one-third to one-half of a cubic foot per stamp per minute. This, includes, however, the water used in the pans, which does not pass through the batteries, and which amounts, perhaps, to one-twelfth or one-eighth of a cubic foot per stamp per minute, leav-

---

*See remarks on this subject at page 734 of my last report.—R. W. R.

†This arrangement also permits the regulation of speed for each battery, according to the nature of ore crushed, etc. In a mill so arranged, experiments to determine the best rate of speed could be easily instituted.—R. W. R.

‡ See my last report, page 736.—R. W. R.

§ Two tons daily for a 650-pound stamp, falling 8¼ inches and giving 75 blows per minute, represent 1.91 tons per horse-power developed at the stamp, a high efficiency, due to speed and the use of Blake's crusher.—R. W. R.

‖ See pages 663, 664, 736 of my last report.—R. W. R.

ing one-fourth of a cubic foot and upward of battery-water per stamp per minute.*

The mills of Virginia City and Gold Hill, that have no springs or other sources of water of their own, are supplied by the Virginia and Gold Hill Water Company. This company obtains water by means of tunnels driven into the hill-side for the purpose, and by purchase from mining companies of their underground waters. Under ordinary circumstances the supply from sources above Virginia City is sufficient for that place, to say nothing of the sources in mines and tunnels lower down. In seasons of drought some inconvenience is experienced.

Water is measured by the miners' inch—the quantity that will pass through an orifice one inch square in the side of the measuring-box, under a head, usually of six inches. In California the aperture is usually made two inches high, and as long as need be to furnish the desired number of inches, and the water in the measuring-box at one side of the supply flume is allowed to stand about six inches above the middle line of the orifice. But this practice is not uniform, and hence the miners' inch has not an invariable value.

The quantity of water that will pass through an orifice one inch square under a head of six inches, determined by multiplying the area of the orifice by the theoretical orifice $\sqrt{2gh}$, and taking two-thirds of the product as effective discharge, is 0.02633 cubic feet per second, 1.578 cubic feet per minute, or 94.68 cubic feet per hour.†

Grinding and amalgamating.—This is performed in pans of various kinds. The objects sought in the different forms of pans are: The most effective form of grinding surface, combining uniform wear with economy of power; free circulation of the pulp; uniform and thorough distribution of the mercury, and the proper degree of heat, insuring favorable conditions for amalgamation; simplicity and cheapness; ease of management and repair; large capacity and economy of time, labor, and material. Probably the highest degree of excellence in all these particulars is not found in any one pan.‡

The most noticeable difference in pans is that of the bottom and grinding surfaces, some being flat, and others conical or curved. Opinions differ as to this feature, but the prevailing opinion seems to favor the flat bottom, though other forms of grinding surface have theoretical advantages, and some pans embodying them, such as Wheeler & Randall's conoidal, and Hepburn & Peterson's conical, are held in high esteem.§ The flat-bottomed pan usually gives more uniform wear, and the various parts of the flat muller are simpler and more easily handled and replaced. The flat muller, carrying its load of thick pulp, requires more power, but, it is claimed, distributes the quicksilver more thoroughly, and thus assists amalgamation.

---

* The average in Colorado is 28 cubic feet of water per cubic foot (125 pounds) of rich ore, or 33 per foot (108 pounds) of poor ore. Per stamp per minute the average is about one-fourth of a cubic foot.—R. W. R.

† This is considerably less than the popular estimate of the (*not* miners') inch, which is 4,032 cubic inches, or 145.86 pounds of water per minute. (See Mr. J. Ross Browne's second report on Mineral Resources, etc., page 184.) Mr. J. Arthur Phillips (Mining and Metallurgy of Gold and Silver, p. 152) agrees exactly with Professor Hague making 60 cubic feet per second equal to 2,280 miners' inches. (See also, for instances of different measurement, my last report, page 477.)—R. W. R.

‡ I omit much on Professor Hague's remarks on pans, since the subject was treated at some length in my last report. His general opinions are, however, fairly given in abridged form.—R. W. R.

§ Where the pan is used more for amalgamation than grinding, as in the case of roasted ores, the flat bottom is certainly preferable.—R. W. R.

Wheeler's ordinary flat-bottomed amalgamator treats a charge of 800 to 1,000 pounds in about four hours; Varney's, about the same; Hepburn & Peterson's, 1,500 pounds, four hours. Wheeler & Randall's takes 3,000 pounds.

McCone's, Horn's, and Fountain's pans have much larger dimensions. They are all flat-bottomed, and are particularly well adapted to the treatment of tailings and low-grade ores. It is claimed in their favor that they treat a charge of ore three or four times as large as that of the ordinary pans in the same or but little longer time, thus economizing labor and power. One large pan requires much less machinery and fewer auxiliary parts than three or four smaller ones of equal aggregate capacity. The attention of the workman is more concentrated, and there is a much smaller loss, proportionately, by wastage of ore, quicksilver, and other materials. While the time allowed for amalgamation is much less in the larger charge than in the smaller one, in proportion to the quantity of ore treated, the results so far seem to be nearly or equally as good. These considerations are of special importance in the working of low-grade ores, which can only be done profitably on a large scale and at small expense per ton, and in which the loss of a small percentage of the value is comparatively trifling in amount. The McCone pan takes 4,500 pounds of pulp, and sometimes more, at a single charge. The Fountain pan works 3,000 to 4,000 pounds of sand at a charge, or about ten tons of tailings daily.

The pans are generally of cast iron, but some varieties have wooden or sheet-iron sides.*

In charging, the muller† is raised a little so as to revolve freely, water, is admitted through hose, and the sand is shoveled in. Steam is introduced either into a steam-chamber in the bottom, or directly into the pulp, the latter method giving higher temperature, but, unless care is taken, too much diluting the pulp, which should be liquid enough for free circulation and thick enough to maintain suspension and equal distribution of the quicksilver. Sometimes both methods are employed, steam being admitted first into the pulp, and afterward into the chamber. Frequently wooden covers to the pans assist in retaining the heat, which, under proper management, may be kept at or near 200° Fahrenheit. When in the use of live steam the pulp becomes too thin, the supply of steam is cut off, the covers removed, and the pulp allowed to thicken by the evaporation of the water, while the temperature is maintained by means of the steam-chamber. Another advantage of the steam-chamber is that the exhaust steam from the engine may be used in it, while for use in the pulp steam is taken directly from the boilers, because the exhaust steam is charged with oil from the cylinder, which injures the amalgamation.

After the commencement of grinding, the muller is gradually lowered and allowed to make about 60 or 70 revolutions a minute. In an hour or two the sand should be reduced to fine pulp. When this has been accomplished, and by some millmen at an earlier stage, even at the beginning, quicksilver is supplied by pressing it through canvas, so as to scatter it upon the pulp in a finely divided condition; the muller is

* And some have wooden sides and stone bottoms. Each form has its advocates.—R. W. R.

† The details of arrangement of mullers, driers, shoes, and dies, are omitted in this abstract. For the general arrangement of the mill see my last report, plate opposite page 114. The mill there given is for dry-crushing. For wet-crushing the drying floor c would be omitted, and tanks introduced to catch the pulp between the battery and the pans. Otherwise the arrangements of the two classes have a general similarity.—R. W. R.

slightly raised from the bottom to avoid too great friction, which would flour the mercury, and the action is continued for two hours longer. The quantity of quicksilver varies in different mills, the ordinary supply being about 60 or 70 pounds to a charge of 1,200 or 1,500 pounds. In some mills a quantity, varying from 75 to 200, or even 300 pounds, is put into a pan when starting after a clean-up, and subsequently a regular addition of 50 or 60 pounds is made with each charge.

The "chemicals" employed to assist amalgamation now consist chiefly of sulphate of copper and salt.* The long list of materials, including tobacco-juice and sage-tea, which have been at various times recommended, has been reduced to these two. The quantity used varies from a quarter or half pound to three or four pounds to each charge of ore; the two substances being employed in different proportions at different mills. It is doubtful whether their use effects any beneficial result, *at least in the manner and proportions in which they are at present employed.*† Different mills illustrate the use of both reagents, of either separately, and of neither, upon apparently similar ores, and with apparently equal success.

After about two hours of grinding, and two or three of amalgamation, the pulp is diluted and discharged into a settler. This is usually a large wooden or iron tub,‡ containing a revolving stirrer, which makes about 15 revolutions per minute, and gently agitates the pulp, to facilitate the settling of the amalgam and quicksilver. In some mills two pans are discharged simultaneously into one settler, and the operation of settling occupies the four hours required to grind and amalgamate another charge. In others, only two hours are allowed for settling, and the two pans connected with each settler are discharged alternately. The amount of water used in diluting the pulp during discharge, or afterward, added in the settler, and the speed of the stirrer, are important conditions of the separation. If the pulp is too thick, the metal remains suspended; if too thin, the sand settles with the metal. Too violent a motion has also the former effect, and too slow a motion the latter. The lighter portion of the pulp is drawn off through holes in the side of the settler, opened at successive intervals by withdrawing plugs at successively lower levels. The quicksilver and amalgam are finally discharged at the bottom.§ In some mills a second settler, called an agitator, receives the stream of pulp from the first, and saves its heaviest portions.

In the arrangement of the mill, the stamp-batteries are placed in one line, with the spalling and charging floor behind them, where the ore is broken and fed to the mortars. The batteries discharge the ore by means of aprons or launders into the settling-tanks. From these it is removed with shovels, and either thrown directly or carried in a car to the pans, which are ranged, when practicable, in a line parallel with the batteries and below them. The settlers again stand in front of the pans in a line, and on a sufficiently lower level to permit the discharge of the pans into them. Below the separators are the agitators or other contrivances, to prevent the escape of quicksilver and amalgam.

Power is usually communicated by gearing or belting from a line-shaft in front of the batteries. Belt-pulleys on this shaft transmit power

* And sulphuric acid.—R. W. R.

† Janin successfully used bluestone and salt on refractory slimes, but in proportions ten or twelve times as great as these.—R. W. R.

‡ An old large pan may sometimes be employed; but all, except the largest pans, are too small.—R. W. R.

§ See drawings and description of a similar apparatus, the "dolly-tub," in the chapter on the Colorado processes, in this volume.—R. W. R.

to the cam-shafts; and counter-shafting and belting perform the same office for the pans and rock-breaker. The pans are usually driven by separate pulleys, arranged on an auxiliary line-shaft, under the row of pans, which receives its power from the main shaft. The power required for each stamp of ordinary or average weight, with due allowance for friction, is about one and a half horse-power.* The power demanded for a pan is from three to six horse-power, according to its capacity. The expenditure of power per ton of ore crushed, ground, and amalgamated, judging by the relation existing between the power of the engines provided, and the work performed by the mills, is between one and a half and three horse-power, averaging, probably, about two, but varying according to the capacity and economy of the mill.

The quicksilver charged with amalgam is carefully cleaned by washing and skimming, and strained through a canvas filter, which retains the amalgam. When this straining is performed, not after every charge of ore, but at longer intervals, a considerable quantity of the fluid quicksilver solution of amalgam accumulates, and this is frequently returned to the pans, as its "charged" condition is thought to render it more active than pure metal in the amalgamating process.†

Pans and settlers are thoroughly cleaned at stated intervals, or on special occasions, all the iron work being carefully scraped with a knife to collect the adhering hard amalgam. In many cases one-fourth, or even a larger proportion of the total product of amalgam is obtained in this way.

Retorting and melting.—The amalgam, having been strained and forcibly pressed, to expel as far as practicable the fluid quicksilver, is then subjected to the process of sublimation in cast-iron retorts, from which the quicksilver, escaping and condensing in the exhaust-pipe, passes into a receiver, where it is collected under water, while the crude bullion remains behind.

The retort is usually cylindrical, abont 12 inches in inside diameter, and 3 to 5 feet long, the casting being 1½ inch thick. The front end is closed with a cover which is tightly fastened and luted with clay after the introduction of the charge. The opposite end is usually conoidal in form, contracting to a diameter of 2½ inches where it connects with the exhaust-pipe, turning downward into the condenser. The retort is set in a brick furnace with suitable fire-place, dampers, and flues.

The amalgam is charged, sometimes in iron trays, sometimes directly upon the bottom of the retort, the iron surface in either case being previously covered with a thin wash of clay or battery-slime to prevent the adherence of the metals. Whiting, wood-ashes, and paper are recommended for this purpose, as less likely to choke the pores of the bullion.

The amalgam being charged, and the door properly closed and luted, heat is applied, at first gently and afterward with gradually increasing intensity. Too high initial heat is likely to fuse the surface of the bullion and prevent the escape of quicksilver from within. When quicksilver ceases to pass over into the receiver, the retort is gradually cooled and the bullion withdrawn. The charge for a cylinder of the dimensions above described is about 1,200 pounds, and the usual time of firing about eight hours. About one-sixth of the charge, or 200

* The horse-power developed by a 650-pound stamp, dropping 8½ inches ($\frac{17}{24}$ feet) 75 times per minute, is $\frac{650\times17\times75}{24\times33,000}=1.15$ horse-power. About 30 per cent. is added for friction in gearing and between cam and tappet, and for the power expended in revolving the stamp.—R. W. R.

† The strained mercury is also more or less "charged" with amalgam. Only after retorting is it free.—R. W. R.

pounds of crude bullion from 1,200 pounds of amalgam, is usually obtained from the retort, to be broken up, melted, and cast in ingots ready for market. The loss of weight in melting is between 2 and 3 per cent. The ingots are assayed, and their fineness, (in thousandths of gold and silver,) with their coin value in dollars and cents, is stamped upon them. The value of the ounce of bullion ready for market usually varies between \$1 75 and \$2; the gold representing about one-third and the silver about two-thirds of the whole amount.

Slimes and tailings.—The term "tailings" is applied to the sand or pulp leaving the settler or agitator. The term "slimes" generally applies to that portion of the ore which is crushed under the stamps to an impalpably fine condition, and usually passes out of the mill without being deposited in the tanks when the coarser sands are collected for pan treatment. That part of the tailings which by grinding in the pans has been reduced to a slimy condition is sometimes called "pan slimes," and thus distinguished from "battery slimes."*

The battery slimes are usually allowed to escape, or only caught in reservoirs below those of the tailings. The tailings are variously treated to extract the quicksilver and amalgam which they still retain. Concentrators, blanket-sluices, etc., are used for this purpose, or large reservoirs are constructed in which the tailings accumulate, and after months of exposure to the weather are worked over again with profit.

The ordinary result of the pan treatment is 65 to 75 per cent. of the assay value. The subsequent treatment of the tailings may increase it to 85 or 90 per cent., or even more.

The stream of water carrying the tailings out of the mill is usually passed over blanket-sluices, to save amalgam, mercury, and heavy particles of ore. These sluices or tables are shallow troughs about 20 inches wide, with sides an inch or two high, and of indefinite length. A number are usually placed side by side—sometimes two, three, or four, sometimes fifteen or twenty, with a fall of 6 to 12 inches in every 12 feet. They are covered with strips of coarse blanket about 2 feet wide, made for the purpose, and cut into lengths of 10 or 15 feet to facilitate removal and washing. As the stream of tailings runs over them they retain the heavier portions, while the poorer sand is washed away, the quantity of water being carefully regulated to produce this effect. An attendant usually sweeps the surface lightly with a broom, distributing the material and assisting the action of the water. The blankets are taken up at intervals usually of twelve hours and washed out in a tub of water. While the blankets of one table are washing, the stream is turned so as to run over the neighboring table or tables.†

In each of the principal cañons below Virginia City are continuous series of blanket-sluices aggregating several miles in length. Some are owned by the mills, but generally they belong to contractors. According to the report of the surveyor general there were, in 1866, over 2,200 feet of blanket-sluices in Six-mile Cañon alone. Their cost is estimated at \$1 per foot, including blankets.‡

* The Comstock slimes are richer than the tailings, because they contain a larger proportion of rich sulphurets. For the same reason they are much more difficult of treatment, their fineness being unfavorable to concentration, and their mineralogical character to simple amalgamation.—R. W. R.

† The stream being constant, the advantage of having more than two tables side by side is evident. One extra table is required, and no more, whether the number in use be one or a dozen.—R. W. R.

‡ For the last two or three years the profits of the blanket-sluice owners have been declining by reason of the low grade of ore worked at the mills, and the greater economy of operations there rendering the tailings less valuable. Sudden freshets in the cañons have damaged this kind of property, and swept away accumulations of tailings.—R. W. R.

The concentrations washed from the blankets are worked in pans, and usually yield from $18 or $20 to $30 per ton.

Treatment of tailings.—After passing the blanket-tables, or other concentrating apparatus, the tailings accumulate in reservoirs. The largest of these are on the plains near the mouths of the cañons. Thus two or three reservoirs at Dayton, near the mouth of Gold Hill Cañon, contain at present, perhaps, 400,000 tons of tailings; the Carson reservoir, receiving the stream from Six-mile Cañon, contains not less than 200,000 tons. A smaller reservoir two miles up the cañon was formerly estimated to contain 100,000 tons; but a large portion has been swept away by freshets. The assays of the slimy and richer parts* of the tailings may show a value $25 or $30 per ton, while the coarse sands vary in value from $4 or $5, to $12 or $15 per ton, according to the original character of the ore and the efficiency of the mill process to which it has been subjected. The contents of some of the smaller reservoirs about Dayton are said to have an average value of $16 to $18 per ton, though the larger reservoirs are probably less rich, a number of assays giving results varying from $9 to $13 per ton. The Carson reservoir has been tested by many assays, varying between $7 50 and $25, averaging about $13 per ton.

Tailings are usually treated by raw amalgamation, a business which occupies a number of establishments. The largest of these is Birdsall's Mill, at Dayton, which was formerly a custom crushing-mill, with thirty stamps and twenty Wheeler pans. The stamps are not now required, and ten or fifteen large pans have been added, so that the mill can amalgamate 250 to 300 tons of tailings daily. The Carson River furnishes ample water-power.

Janin and Baldwin's Dayton Mill, also at Dayton, has five McCone pans, with a capacity of about 50 tons per day. It is driven by steam. Each pan works a charge of 4,000 or 5,000 pounds and four or five charges per day. Sulphate of copper and salt are supplied to the pans with each charge, of the former 3 to 6 pounds per ton, and of the latter 20 to 30 pounds—a large excess. The pans are covered and supplied with steam, maintaining a high temperature. The yield is thought to be about 60 per cent. of the assay value, which is said to average $16 or $18 per ton. From the accounts of this mill, it appears that during five months ending October 31, 1869, the quantity worked was 6,732 tons, of which the average yield was $9 75 per ton. The total expense, including extraordinary repairs, (refitting mill and purchasing new pans,) was $43,672, or $6 48 per ton. The current ordinary expense appears to have been, per ton—

For labor	$1 40
Quicksilver lost	95
Salt	68
Sulphate of copper	65
Fuel	1 20
Castings	12
	5 00

* The quality of the tailings in a reservoir is frequently affected by the proportion of slimes retained with the tailings. The slimes remaining, by reason of their fineness, longer suspended in water, may settle at the lower end of the reservoir, along the dam, or they may be carried over and either lost or caught in some other reservoir below. The curious phenomenon is thus presented of the removal by the stream of the very richest and the very poorest portions of the ore. But tailings containing a small proportion of slimes, though they assay higher in consequence, do not always yield more under the ordinary pan treatment—a circumstance which has ere now brought purchasers and contractors to grief.—R. W. R.

The mill employs seventeen men, viz: one foreman, five amalgamators, (three by day and two by night,) two engineers, one wood-passer, three teamsters, (bringing tailings from the reservoir,) and five shovelers, (loading teams and turning tailings over to dry.) The tailings here treated are somewhat richer than ordinary, and require more chemicals. Wood is also expensive here, costing $10, and more, per cord. Tailings of lower grade, treated with less chemicals, more quickly, in mills of greater capacity, and with cheaper fuel, would require proportionately less outlay in running expense. Thus at Avery's tailing mills in Washoe Valley, where wood is $6 per cord, the cost per ton is said to be but $3 50.

Treatment of slimes.—All attempts to work slimes by raw amalgamation in pans (*i. e.*, without previous roasting) were for a long time unsuccessful. This was attributed partly to the finely divided, clayey condition of the material, by reason of which the quicksilver and amalgam became coated with a slimy film, preventing amalgamation and causing great mechanical loss of mercury; partly also to the probable presence of the silver as sulphurets, as in the first-class ores, which require a chloridizing roasting to prepare them for amalgamation. Roasting being too expensive, under the circumstances, for slimes, this material has been either mixed with tailings, (or thrown back into the battery pulp,) and worked over in the pans, in which case it is impossible to say how much of its value has been extracted; or it has been allowed to run off with the common tailings, and be caught, sometimes in the great reservoirs at the cañon mouths, sometimes by special dams constructed for the purpose.*

Within a year or two past, however, slimes have been successfully treated in pans, without roasting, by a process which differs from the ordinary pan amalgamation of fresh ores or tailings, chiefly in the quantities of chemical reagents employed.† The mills of Messrs. Janin and Mr. I. S. Parke, in Six-mile Cañon, have reduced with profit, in this manner, large quantities of slimes.

In the Janin mill there are four McCone pans, receiving 2,500 pounds of slime at each charge.‡ Twelve pounds of the sulphate of copper and thirty-six pounds of salt are added with each charge, and the whole is worked for two hours before putting in the quicksilver. Little or no grinding is required, as the material is already exceedingly fine; the muller is raised high enough to avoid unnecessary friction, and revolved at the speed usual in working ore, the object being to keep up the circulation of the pulp. After two hours the quicksilver is added in large quantity, usually 300 pounds. The charge is then worked four hours longer, and afterward drawn off into the settler; when the amalgam is collected, while the residue is passed through large agitators, before finding its way to the tailing-stream, in order to save as much as possible of the escaping amalgam and quicksilver. The employment of so much quicksilver, together with the clayey nature of the slimes, causes a large loss of that metal, said to be about five pounds to the ton of

* It is unfortunate that the plan of saving slimes in reservoirs was not put in operation in the early days of Washoe mining, when this material was enormous in quantity and very rich. Millions of dollars were lost by this neglect, never to be recovered unless the Carson River may be made to "give up its dead."—R. W. R.

† Messrs. Louis and Henry Janin deserve the credit of solving this problem, both theoretically and practically. With characteristic intelligence and skill, they experimented in the direction indicated by scientific principles, and opened to the limited pan process a new realm of possible applications, the boundary of which is not yet determined.—R. W. R.

‡ The regular charge of ore would be 4,000 or 5,000 pounds; but slimes increase greatly in bulk on the addition of water.—R. W. R.

slimes. This item and the liberal use of chemicals raise the cost of treatment to probably not less than $12 per ton. The supply of slimes is obtained by purchase from the mills,* their value being previously determined by assay. It varies from $25 to $30 per ton; and the purchase price for some time past has been from $3 to $5 per ton. It is said that this process extracts upward of 60, and frequently 80 per cent. of the assay value.

In Mr. Parke's mill a similar method is followed, except that wooden pans, with riffled or corrugated wooden side-lining and cast-iron bottoms are employed, and are said to facilitate greatly the disintegration of the slimes, which tend to aggregation in tenacious clayey lumps.

The roasting of slimes, though metallurgically a rational method, has not been economically successful, in view of the cost of fuel and labor. It has been attempted in the O'Hara furnace with promising experimental results, which were never followed up; and it has been proposed to apply the Stetefeldt furnace † to this purpose. Ordinary reverberatories are certainly too expensive.

Treatment of first-class ores.—The quantity of high-grade ore now produced from the Comstock mines is so small that it but partially employs the single mill of Mr. Dall, in Washoe Valley. The process is drying, dry-crushing with stamps, roasting with salt, amalgamation in barrels, and retorting. ‡ The roasting is performed in reverberatories, for which the Stetefeldt furnace is a modern and more economical substitute in use elsewhere.§ Pans are likewise employed instead of barrels in other parts of Nevada and in Colorado. At this mill, wood costing $5 per cord, common labor $3 per day, salt 3 cents per pound, and quicksilver 65 cents per pound, the price charged for reduction was $40 to $45 per ton, with a guarantee of the return of 80 per cent. of the assay value of the ore. That is to say, the mill in effect purchases first-class ore for 80 per cent. of its value, less $40 or $45 per ton, the stipulated price for working, making its return in cash or bullion, without any statement of the yield actually obtained.

CHEMISTRY OF THE WASHOE PROCESS.

This subject has been but little understood, though much discussed, a fact which need not surprise us when we reflect that the same is true of the chemical reactions involved in the manufacture of iron, and, indeed, of all processes which have grown up, step by step, out of the needs of daily practice. The great difficulty in the way of reasoning from the facts to the principles underlying them has been the imperfection of the data. Millmen have no time to make scientific, that is to say, carefully-guarded and recorded, experiments. They are satisfied with profitable results, and do not inquire into causes, except in case of loss. But the most important sources of loss in the Washoe process, as employed on

* The discovery of a successful treatment for slimes had the effect of raising the value of this material in the estimation of the owners of reservoirs; and the Messrs. Janin found it difficult to control a permanent supply at prices which would leave them a sufficient profit, especially as the margin of gain must needs be large in a business based upon the purchase of such material by assay. It is my impression that they closed their mill last year on this account.—R. W. R.

† For descriptions of these furnaces, see my report of 1870, pp. 743, 749.—R. W. R.

‡ Essentially the "Reese River process," described in my report of 1870, p. 733.—R. W. R.

§ The great saving in the cost of roasting, by the use of the Stetefeldt furnace, is incontestable; but the full realization of this advantage requires an adequate supply of ores. The supply of high-grade ores from the Comstock mines is at present far beneath the capacity of a single Stetefeldt furnace.—R. W. R.

Comstock ores, are mechanical defects in the apparatus and lack of honesty or faithfulness in the workmen. Hence, the best mechanic and most vigilant overseer makes, in most cases, with but a slight addition of metallurgical knowledge, the best millman, and his little superstitions about this or that chemical agent do not interfere with his general efficiency. There is no doubt, however, that a careful study and comparison of experience in this process would raise the general average of its economy materially.

Mr. Arnold Hague contributes a chapter on the subject to the volume of the United States Geological Exploration of the Fortieth Parallel, so frequently quoted in the present report. His investigation of it is based upon experiments, carefully conducted, on a small scale at the Sheffield Laboratory of Yale College. Mr. Ellsworth Daggett, a practical millman, assisted in these experiments, and two lots of ore, one of first class from the Savage mine, and the other of low grade from the Kentuck, were operated upon. In addition to these practical tests numerous minor experiments were made to clear up doubtful questions of chemical reaction. I shall quote the larger part of Mr. Hague's chapter. There is no doubt of the general accuracy of the experiments, but there are two possibilities of error in the reasoning. One is, that the ore tested may not have been perfectly representative of the Washoe ores; the other is, that the small scale of operations may have affected the reactions. The fact that native silver is not recognized in the analyses, whereas this has always been considered an ingredient of the Comstock ore, and has been held by some metallurgists to be the only or principal form of the silver actually extracted by raw amalgamation, hints at the first source of error above mentioned. But Mr. Hague's treatise is admirable in the fidelity with which it reports grounds, as well as conclusions. In condensing it, its peculiar value as a contribution to the body of trustworthy evidence on this important subject would be destroyed; hence the essential portions are quoted entire.

The average ore as it comes from the mines presents to the eye a mass of nearly white, brittle, crumbling quartz, ranging in size from fine dust to pieces that weigh several pounds; occurring with it are small fragments of wall-rock and clay, that impart a somewhat grayish tinge. An inspection of the ore piles at the different mines and mills generally shows the presence of iron and copper pyrites. Except in first-class ore, which is always roasted before being sent to the amalgamating pan, it requires a somewhat closer examination to detect well-defined specimens of other minerals, so finely are they disseminated through the entire mass. A more careful search, however, will generally develop the presence of blende, galena, and argentite; more rarely, polybasite and stephanite.

Samples of finely-crushed ores were subjected to a microscopical examination. The following minerals were observed: quartz, small cubes and particles of iron and copper pyrites, flakes of blende, and thin pieces of a dark lead-gray mineral, which were determined to be argentite.

In order to determine the chemical and mineralogical composition of the ore more accurately, samples of carefully chosen first and third-class rock were subjected to a thorough analysis. The first-class came from the Savage mine, and was taken from a lot of ore that had been crushed at Dall's Mill. Its assay value was $489 22. The third-class ore came from the Kentuck mines; it was obtained at the mill from the troughs immediately after leaving the batteries, in the same manner as the mill samples are ordinarily taken. The material used was selected from 300 to 400 pounds of crushed rock, collected at intervals during a day's run of twenty-four hours. Its assay value was $43 74.

The results of both analyses were as follows: No. 1, Savage ore;* No. 2, Kentuck ore:

* Assayed by Mr. William G. Mixter.

	No. 1.	No. 2.
Silica	83.95	91.49
Alumina	1.25	1.13
Protoxide of iron	1.95	.83
Protoxide of manganese	.64	....
Lime	.85	1.42
Magnesia	2.82	1.37
Potash and soda	1.28	1.05
Sulphide of zinc	1.75	.13
Sulphide of lead	.36	.02
Sulphide of silver	1.08	.12
Subsulphide of copper	.30	.41
Gold	.02	.0017
Bisulphide of iron	1.80	.92
Moisture	2.33	.59
	100.38	99.48

No arsenic or antimony was detected in either case, not even after subjecting considerable quantities to Marsh's test. It is, therefore, inferred that stephanite and polybasite were both absent. It was found impossible to separate the native silver, if any was present, from that existing as argentite; of the former none was observed, but the latter could be recognized under a glass; it is, therefore, all calculated as sulphide of silver. The sulphur obtained has been combined with the zinc as blende, with lead as galena, with silver as argentite, with copper as subsulphide, and the remainder with iron as bisulphide. The iron still remaining has been estimated as protoxide. It was found impossible to separate the metallic iron, coming from the stamps of the batteries, from the sesquioxide of iron, occurring in the rock and clay material of the vein. The substances found in both analyses are the same, with the exception of there being no manganese in the sample from the Kentuck mine, the differences being only the variable proportions of the same minerals. If in the two analyses we reject the gangue and such matter as can have no other influence upon the extraction of the precious metals than a physical one, by affecting the mechanical conditions in the grinding of the ore, or the consistency of the pulp, and consider only those ingredients that may influence the chemical conditions during the operation in the pan, we have the following:

	No. 1.	No. 2.
Protoxide of iron	1.95	.83
Bisulphide of iron	1.80	.92
Subsulphide of copper	.30	.41
Sulphide of zinc	1.75	.13
Sulphide of lead	.36	.02
Sulphide of silver	1.08	.12
Gold	.02	.0017
	7.26	2.4317

Chemical action of mercury and other reagents.—The ore of the Comstock vein may be regarded as composed of the following:

Gangue, quartz.

Metal-bearing minerals of common occurrence: Blende, galena, argentite, silver, gold, iron pyrites, copper pyrites.

Minerals of much more rare occurrence: Stephanite, polybasite.

The following experiments were undertaken to ascertain, as far as possible, the action upon the minerals of the Comstock ores, just enumerated, of mercury, and such chemical agents as are employed in the amalgamation process, or may be formed during the operation in the pan:

Mercury and native silver, when rubbed together, unite easily.

Mercury and chloride of silver, the latter prepared in the wet way, when brought in contact, form amalgam and chloride of mercury.

Mercury and argentite: The mineral was first pulverized and mixed with a little

fine sand, the metal added, and the mass allowed to stand for some time; occasionally rubbed together in a mortar. Amalgamation ensued; it was, however, imperfect, much of the mineral being unacted upon.

Mercury with stephanite and polybasite, under the same conditions as the last experiment, gave similar results; the decomposition, however, appeared to be more complete, probably owing to the more finely divided state of these minerals than the more sectile argentite.

The above experiments with native silver, chloride of silver, argentite, and polybasite, were repeated with mercury containing a small quantity of copper-amalgam in solution. In the case of the two former there was the same action as when the pure metal was used; with the two latter the decomposition was more perfect and satisfactory.

Chloride of silver, argentite, and stephanite were each subjected to the action of mercury and fine metallic iron, with a constant application of heat. The energy displayed by the mercury was much more marked than when employed separately. In the case of the chloride, the decomposition was quite rapid, and the surface of the metal remained bright and clean.

Chloride of copper and pulverized argentite were allowed to stand together for ten days, in the cold, with an occasional application of heat, at the end of which time, a small quantity of chloride of silver was formed. A trace of sulphuric acid was found in the filtrate.

Two grammes of the pulverized mineral were also treated with a moderately concentrated solution of chloride of copper placed in a bottle, with a tightly-fitting stopper, to prevent access of air. It was exposed for twenty-four hours to a temperature of 90° centigrade. Sulphuric acid and sub-chloride of copper were found in the solution. Chloride of silver was precipitated. After removing the soluble salts, by washing, the chloride of silver was dissolved out, by digesting it with ammonia. The residue gave, by assay, .099 grammes of silver. Two grammes of the mineral produced .1705 of pure metal; showing that under the most favorable conditions but little over one-half of the silver was chloridized. The application of heat greatly facilitated the decomposition.

Polybasite, after being subjected to the chloride of copper solution, at the ordinary temperature of air, also yielded a small quantity of the chloridized silver.

Argentite was exposed to the same treatment, with sub-chloride of copper, as in the last experiments. In the cold, decomposition ensued after standing several days. The residue from two grammes of the mineral, subjected to the action of heat at 90° centigrade, without access of air, gave .1655 of a gramme of silver, showing that only .003 had been chloridized.

Galena, in a pulverized condition, was digested with a strong mixture of salt and sulphate of copper, and after standing three or four weeks, at the ordinary temperature, was filtered. The residue exhibited, besides the undecomposed mineral, a light green oxychloride of copper, and a large quantity of sulphate of lead incrusting the galena.

Blende was also subjected to a similar treatment. The solution was found to contain a considerable quantity of oxide of zinc, and but little copper. The residual blende was coated with the same oxychloride of copper already noted in the case of the galena.

Two grammes of the powdered mineral were placed in a flask, a solution of five grammes of salt and seven of sulphate of copper added, and exposed for two days to a temperature of 90° centigrade. After remaining three days longer in the cold the amount of oxide of zinc found to have been dissolved was .2785 of a gramme. The same experiment was repeated with the addition of one gramme of iron filings. The latter rapidly disappeared; metallic copper was precipitated, but was redissolved, probably by the chloride of copper present, the sub-chloride being produced. Later, the iron was thrown down as a basic salt. The oxide of zinc estimated in the solution was .3250 of a gramme.

Iron and copper pyrites are but slightly altered by the copper solutions. In practical operations at the mill they are found in the tailings without showing any appreciable signs of having been attacked.

It will be observed in the above experiments that the argentiferous sulphurets were always more or less chloridized by the action of the copper salts.

In order to indicate more clearly the relative amount of decomposition produced by the two chlorides of copper, the results are here brought together as follows: Two grammes of argentite gave .1705 grammes of silver. After treating two grammes of the mineral with chloride of copper, the residue gave .099 grammes of silver; after treating two grammes of the mineral with sub-chloride, the residue gave .1653 grammes of silver; showing that in the former 58.0 per cent., and in the latter, 2.9 per cent. was chloridized. No sulphide of copper was detected in any of the residues examined; sulphuric acid, however, was found in the filtrate in several instances.

Pan experiments.—With a view to determine, if possible, some of the problems in-

volved in the action of mercury, common salt, and sulphate of copper, employed in the decomposition of the Comstock ores by the Washoe process, the experiments described in the following pages were undertaken upon two lots of ore, whose composition was well known.

It was necessary, in order to make the investigations of any practical value, that the material should be treated in such a manner as to imitate as closely as possible the operations carried out on a large scale at the mills, and at the same time to be able to repeat precisely the same conditions as often as desired, and to know the exact results of each trial.

Of the ores used, one was a lot of first-class rock from the Savage mine, such as is ordinarily sent, on account of its high value and large amount of base metals, to Dall's Mill, for reduction by the barrel process, as described in a previous chapter. The second lot consisted of several hundred pounds of third-class ore from the Kentuck mine, presented, for the purposes of the work, by the Kentuck Mining Company. This low-grade ore was selected as being well adapted for pan amalgamation; easily reduced, containing but little base metal, and the rock from which it was taken yielding very favorable results at the mill. Both ores were carefully and thoroughly sampled, and passed through a fine sieve in order that they might be well mixed. Repeated assays were made until they had as uniform a composition as it was possible to obtain. After which, to prevent any settling of the heavier particles, both lots were put up in bags, in quantities of 10 and 15 pounds each; from several of these parcels assays were made, and the results found to agree. The Savage ore assayed, gold, $134 35; silver, $354 87; total, $489 22 per ton. The Kentuck ore assayed, gold, $10 85; silver, $32 89; total, $43 74 per ton. The results of the chemical analyses of both samples are given above.

A small amalgamating pan, such as is used in California for the purpose of experimenting upon new ores, was procured. It was made by Mr. Wheeler as a test pan, and in all its essential features was similar to the larger ones of his manufacture, employed in milling operations. It was 18 inches in diameter, and capable of working 20 pounds at a charge. A wooden tub, 3 feet in diameter, 18 inches deep, and provided with four wooden arms, connected with and revolved by an upright shaft in the center, served to keep the pulp in constant motion, and answered all the requirements of a settler or an agitator. A room with steam-power was secured and a mill upon a small scale set up, which supplied all the necessary conditions of a larger establishment.

The manner of conducting the operations was the same in every case; the ore was first placed in the pan, the muller set in motion, water added to bring the pulp to the proper consistency, and steam admitted to a chamber below. As soon as the pulp was thoroughly heated, the salt, sulphate of copper, or such other chemical agents as were employed, after being carefully weighed, were thrown in. The mercury was immediately added, in a fine condition, being strained through buckskin. Care was always taken to maintain the pulp at the proper degree of consistency, and to preserve a constant heat, which was frequently tested by means of a thermometer plunged into the pan. A temperature of 185° Fahr. was found to act most advantageously. The pan worked well; the grinding action was perfectly satisfactory; the ore being kept in a constant and rapid circulation, and the mercury finely disseminated through the entire mass. The muller made 118 revolutions per minute.

The operation concluded, the pulp was drawn off into the settler, the pan thoroughly washed out, or "cleaned up," and every particle of amalgam removed.

An additional quantity of mercury was placed in the settler, and water poured in until it was about half full. The stirrers made 30 revolutions per minute. The pulp was withdrawn at the end of four hours. The water, and the very lightest material, was allowed to escape, but the great bulk of sand and mercury was collected together in buckets and separated by hand, to avoid all loss. In washing, the tailings were made to fall upon a slightly inclined table, or trough, so that if, by any accident, mercury went over it could be easily recovered.

The quicksilver, after being washed free from sand, was strained through buckskin, and the amalgam collected for retorting.

The difference in weight between the mercury used in the pan and settler, and that which remained at the conclusion of a charge, after adding the amount retained in the bullion, was in most cases scarcely appreciable. Owing to the well-known property of mercury to retain a small portion of silver in solution, which the ordinary pressure used in separating the bullion fails to recover, the precaution was taken to have it all previously primed or charged before adding it to the pan. This was accomplished by allowing the mercury and metallic silver to stand in contact for some time, and then straining off the amalgam formed.

The amalgam obtained from each experiment was weighed and put separately in small sheet-iron cups. The number of each charge being stamped plainly on the inside, several of them were then placed together, on the bottom of a small cast-iron retort, and the mercury distilled over. After the retort had cooled down the remaining bullion was taken out and accurately weighed. Careful assays of each lot were made, and always conducted with proofs, and the metals separated by nitric acid in the usual way.

From the amount and fineness of the bullion the actual value of the gold and silver obtained from each charge is determined.

For the purposes of comparison it was considered desirable to maintain, as far as practicable, the same conditions in each trial; for this reason there is very little variety in the treatment with chemical agents, or the duration of the operations. The relative amounts of salt and sulphate of copper employed have in every case been the same; one-half the quantity by weight of the latter to that of the former.

A large excess of mercury and reagents were used in order to point out any marked differences in the results, and at the same time to obtain the greatest possible yield of the precious metals, without regard to the purity of the bullion, or the practical advantage of the method.

The results are given in the accompanying tables; they are recorded precisely as they occurred, although there are in some instances apparent errors:

Table showing the results of experiments upon Kentuck ore.

Number.	Amount of ore.	Chemicals.			Time.	Weight of—		Fineness of bullion.			Actual value extracted.			Value extracted per ton.			Per cent. saved.		Yield per cent.
		Salt.	Sulphate of copper.	Quicksilver.		Amalgam.	Bullion.	Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.	
	Lbs.	Oz.	*Oz.*	*Lbs.*	*H'rs.*	*Grams.*	*Grams.*				*Cents.*	*Cents.*	*Cents.*						
1	20	1	½	4	5	31.850	6.073	21.2	946.4	967.6	07.28	23.82	31.10	$7 28	$23 82	$31 10	67.09	72.42	71.10
2	20	1	½	4	5	33.810	6.214	21.4	940.2	961.6	07.5	24.21	31.71	7 50	24 21	31 71	69.12	73.61	72.49
3	20	......	......	6	5	23.930	3.648	31.8	960.6	992.4	07.78	14.60	22.33	7 73	14 60	22 33	71.24	44.39	51.05
4	20	1	½	6	5	37.200	6.623	13.2	966.0	979.2	05.7	26.55	32.25	5 70	26 55	32 25	52.53	75.3	73.73
5	15	......	......	4	5	25.750	5.322	14.2	967.4	981.6	04.95	21.33	26.28	6 60	28 44	35 04	60.83	86.5	80.11
6	15	......	......	4	5	26.725	4.908	24.6	960.6	985.2	06.88	19.56	26.44	9 17	26 08	35 25	84.57	79.3	80.59
7	15	¾	⅜	4	5	24.240	4.490	24.6	971.8	996.4	06.55	18.05	24.60	8 73	24 07	32 80	80.46	73.18	74.98
8	15	3	1½	4	5	39.350	6.811	22.8	689.4	712.2	08.48	19.48	27.96	11 31	25 97	37 28	104.3	78.96	85.23
9	15	3	1½	4	5	39.350	6.967	23.6	670.0	693.6	08.7	19.35	28.05	11 60	25 80	37 40	106.9	78.44	85.51
10	15	......	......	4	5	27.500	5.707	28.2	968.6	996.8	09.5	22.92	32.42	12 67	30 56	43 23	116.7	92.92	98.83
11	15	......	......	4	5	27.500	5.275	24.8	972.4	997.2	07.66	21.27	28.93	10 26	28 36	38 62	94.57	86.23	88.16
12	15	¾	⅜	4	5	30.500	5.685	20.2	973.4	993.6	06.44	20.70	27.14	8 58	27 60	36 18	79.14	83.92	82.73
13	15	¾	⅜	4	5	30.600	5.730	20.2	955.2	975.4	06.49	22.71	29.20	8 65	30 28	38 93	79.72	92.06	89.00
14	15	1½	¾	4	5	32.600	5.830	18.2	947.4	965.6	07.05	22.91	29.96	9 40	30 54	39 94	86.63	92.85	91.08
15	15	2¼	1⅛	4	5	33.400	5.830	16.6	887.2	903.8	06.43	21.45	27.88	8 56	28 60	37 16	78.89	87.26	84.95
16	15	3	1½	4	5	36.000	6.725	12.8	727.2	740.0	05.33	20.29	25.62	7 10	27 05	34 15	65.43	82.24	78.07
17	15	......	Cu_2Cl	4	5	33.500	5.855	14.2	904.8	919.0	05.52	21.99	27.51	7 36	29 32	36 68	67.83	80.14	83.85
18	15	......	Cu_2Cl	4	5	31.400	5.598	15.6	899.0	914.6	07.30	20.89	28.19	9 72	27 85	37 58	89.56	84.67	85.90
19	15	......	......	4	5	29.000	5.160	22.2	963.0	985.2	06.49	20.62	27.11	8 64	27 48	36 12	79.64	83.55	82.57
20	15	4	2	4	5	76.800	10.000	12.4	418.8	431.2	08.24	17.38	25.62	10 98	23 17	34 16	101.19	70.44	78.09
21	15	......	Cu_2Cl	4	4	103.5	31.205	2.7	152.0	154.7	05.60	19.69	25.29	7 47	26 25	33 72	68.84	79.81	77.09
22	15	......	Cu_2Cl	4	4	37.	5.760	16.	897.8	913.8	06.12	21.43	27.55	8 16	28 57	36 73	75.20	86.86	83.97
23	15	1½	$\left\{ FeO\,SO_3\ \tfrac{1}{2} \right\}$ $\left\{ CuO\,SO_3\ \tfrac{1}{2} \right\}$	4	4	36.5	6.053	23.	906.2	929.2	08.06	22.57	30.63	10 75	30 09	40 84	99.08	91.48	93.37

Assay value per ton, gold	$10 85
Assay value per ton, silver	32 89
Total	43 74

Assay value per charge of 15 pounds, gold	$0 08.15
Assay value per charge of 15 pounds, silver	24.72
Total	32.87

Table showing the results of experiments upon Savage ore.

Number.	Amount of ore.	Chemicals.			Time.	Weight of—		Fineness of bullion.			Actual value extracted.			Value extracted per ton.			Per cent. saved.		Yield per cent.
		Salt.	Sulphate of copper.	Quicksilver.		Amalgam.	Bullion.	Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.	
	Lbs.	*Oz.*	*Oz.*	*Lbs.*	*H'rs.*	*Grams.*	*Grams.*				*Cents.*	*Cents.*	*Cents.*						
1	15	......	....	4	5	104.750	20.630	45.2	945.0	990.2	61.89	81.07	142.96	$82 52	$108 10	$190 62	61.42	30.77	38.96
2	15	4	2	4	5	169.750	27.820	44.4	948.6	993.0	82.12	109.45	191.57	109 48	145 92	255 40	81.48	41.11	52.20
3	15	4	2	4	5	135.000	25.190	45.4	945.6	991.0	76.07	98.80	174.87	101 44	131 72	233 16	75.50	37.11	47.65
4	15	......	....	4	6	115.60	19.120	58.0	928.0	986.0	73.71	73.63	147.34	98 28	98 16	196 44	73.15	27.66	40.15
5	15	1	½	4	5	86.	15.930	64.4	933.0	997.4	68.17	51.48	119.65	90 88	68 64	159 52	67.64	19.37	32.60
6	15	......	Cu_2Cl	4	5	184.5	29.950	35.6	950.0	985.6	70.80	118.10	188.90	94 40	157 44	251 84	70.26	44.33	51.47
7	15	......	Cu_2Cl	4	5	181.	30.030	34.6	951.4	986.0	69.02	118.50	187.52	92 04	158 00	250 04	68.57	44.80	51.11
8	10	1½	$FeO\,SO_3$ ½ $CuO\,SO_3$ ½	3	4	64.50	11.679	60.	915.8	975.8	46.56	44.4	90.96	93 12	88 08	181 92	69.38	25.02	37.18
9	10	1½	$FeO\,SO_3$ ½ $CuO\,SO_3$ ½	3	4	85.4	15.571	47.	729.4	776.4	48.63	59.87	108.50	97 26	119 74	217 00	72.39	33.74	44.35
10	10	......	Cu_2Cl	3	4	67.4	12.739	59.6	917.6	977.2	50.79	48.47	99.26	101 58	96 94	198 52	75.60	27.32	40.57
11	10	......	Cu_2Cl	3	4	62.	11.950	59.6	917.6	977.2	47.64	45.46	93.11	95 26	90 91	186 19	70.92	25.64	38.05
12	10	4	2	4	5	87.	15.450	40.	934.8	974.8	41.06	59.94	101.01	82 12	119 88	202 00	61.12	33.78	41.28

Assay value per ton, gold	$134 35	Assay value per charge of 15 pounds, gold	$1 01.01
Assay value per ton, silver	354 87	Assay value per charge of 15 pounds, silver	2 66.81
Total	489 22	Total	3 67.81

Notes accompanying the experiments upon the Kentuck ore.

Nos. 1 to 20. Fifteen pounds of mercury added to the settler.

Nos. 21 to 23. Ten pounds of mercury added to the settler.

No. 3. No reason is known for the low yield both of gold and silver; the amalgam looked well and the fineness was very high.

Nos. 8, 9, 10. These charges gave a higher gold return than any of the assays of the ore. No sufficient explanation can be assigned for the fact. The assays of the bullion were carefully repeated with the same results. Charge No. 10 shows the greatest difference between the assay and the yield, in which case it is less than fourteen mills' worth of gold in excess of the amount assumed from the assay to be present. This excess may probably be accounted for by errors in the manipulation that the ore was subjected to during the treatment in the pan and settler. It is possible that the mercury when strained yielded a trifle more gold than usual. The fact is worthy of mention that all the charges that show an excess of gold, with the exception of No. 20, follow each other consecutively.

Nos. 17, 18. The sub-chloride of copper was added in a solution of salt. The quantity of copper was equivalent to the amount contained in one ounce of the sulphate of that metal.

No. 23. The quantity of copper corresponded to two ounces of the sulphate of the metal.

Notes accompanying the experiments upon the Savage ore.

Nos. 1 to 7. Fifteen pounds of mercury added to the settler.

Nos. 8 to 12. Ten pounds of mercury added to the settler.

No. 4. The pan by mistake ran six hours instead of five.

No. 5. No cause could be assigned for the low return of bullion.

Nos. 6, 7. The solution of sub-chloride of copper was the same as employed with Nos. 17 and 18 of the Kentuck ore.

Nos. 11, 12. The solution of sub-chloride of copper was the same as employed with No. 23 of the Kentuck ore.

It must be admitted that the results obtained in the above experiments are not, in all respects, satisfactory, nor do they point out conclusively the action and value of salt and sulphate of copper in the decomposition of the argentiferous ores by the Washoe process. They throw some light, however, upon several important points.

In considering the results, as shown in the tables, the most marked feature is the difference in the yield of the gold and silver bullion extracted from the two ores relative to the assay value. There is, with but one exception, in every trial of the Kentuck rock a higher yield than the requirements of the mines demand of the mills, and, in most cases, it is very much larger than is usually returned under the most favorable circumstances, in practical operation. This is probably owing, in a great measure, to the large amount of mercury employed in proportion to the quantity of ore. The Kentuck also gave as favorable results where mercury alone was used as when chemical agents were added. This proves very decidedly the ability of quicksilver, aided by heat and iron, to decompose the purer and easily reducible argentiferous minerals.

With the Savage ore it may be observed that the yield is in all cases not only very much below that from the Kentuck, but lower than the average returns from the mills upon ores that are not first subjected to a roasting process. This is undoubtedly due to the large percentage of blende and galena present, with which the precious metals are in combination. The use of chemical agents shows a decided improvement in the production of bullion from such ores as contain large quantities of base metals. The application of salt and sulphate of copper did not increase the loss of mercury, although in many charges large quantities were present in the pulp. In the experiments conducted, with every possible precaution to repeat the precise conditions of a charge, using the same quantities of salt, sulphate of copper, and mercury, the results differ as widely as in those cases where the amount of chemical agents employed are much less, or entirely abandoned. The cause of these great differences in the yield of bullion must be sought elsewhere than in the varying amounts of the chemical agents used, however important they may be, in certain cases, in aiding and assisting decomposition. A favorable yield undoubtedly depends more upon the native condition of the mercury than anything that is usually added to the pulp. Charges 8, 9, 10, 11, of the Savage table, ran only four hours, which may in some degree account for the low yield. Charge 12 ran five hours with a somewhat higher result. It should be stated that the mercury of charges 11 and 12 appeared to contain a small amount of lead, which may have rendered it partially inactive. Charges 21, 22, and 23, of the Kentuck table, were discharged at the end of four hours, without any marked decrease in the production of bullion. It seems probable that in the case of the latter the minerals are all easily reduced, and the amalgamation is practically accomplished in the allotted space of time. In the case of the Savage ore the base metals are but slightly attacked

by the mercury, and require more time for any chemical changes before amalgamation can take place. There is considerable resemblance between Nos. 3 and 4 of the Savage table, with a large excess of salt and sulphate of copper, and Nos. 6 and 7 with a solution of the sub-chloride of copper. The reason may be found in the fact that in the former the chloride of copper formed would be quickly reduced by the iron to the state of the sub-chloride, and similar conditions produced as in the case of the latter.

Chemistry of the process.—The action and value of common salt and sulphate of copper in the amalgamation of argentiferous ores, by what is known as the patio process, has always been a somewhat disputed question. Numerous theories have been advanced by metallurgists of long practical experience in Mexico, to account for the reduction of the sulphide of silver by the methods adopted in that country. The two which have obtained the most prominence, and which chemists have received with most favor, differ very widely in the manner the decomposition is supposed to be accomplished.

The most plausible theory, and the one now generally adopted, is that of Sonnenschmidt. He claims that the salt and sulphate of copper react upon each other, and produce sulphate of soda, which is neutral in its action, and chloride of copper. This latter salt then acts upon the argentiferous sulphide, and yields chloride of silver, sub-chloride of copper, and free sulphur. The sub-chloride reduces a second portion of the sulphide of silver, and causes the formation of an additional amount of the silver chloride, and sub-sulphide of copper. The silver salt is then attacked by the mercury; calomel, or sub-chloride of mercury, is produced, while metallic silver is set free, which combines with a second portion of the mercury, as amalgam.

The following chemical equations show the reactions:

$$NaCl + CuOSO_3 = NaOSO_3 + CuCl$$
$$2\,CuCl + AgS = AgCl + Cu_2Cl + S$$
$$Cu_2Cl + AgS = AgCl + Cu_2S$$
$$AgCl + Hg = AgHg + Hg_2Cl.$$

Bowring, an English metallurgist, on the other hand, denies that any of the sulphide of silver is chloridized, and asserts that before amalgamation takes place, metallic silver is first produced. He claims that chloride of copper, in contact with mercury, forms the sub-chloride of both metals. The sub-chloride of copper, in contact with the oxygen of air, is converted into an oxychloride, which, in turn, acts upon the sulphide of silver, and liberates the metal in a free state, by oxydizing the combined sulphur. These reactions are expressed as follows:

$$2\,CuCl + 2\,Hg = Cu_2Cl + Hg_2Cl$$
$$Cu_2Cl + O = CuCl\ CuO$$
$$3\,(CuCl\ CuO) + AgS = Ag + SO_3 + 3\,Cu_2Cl.$$

Although oxychloride of copper may possibly be found at times, there does not appear to be any decided evidence that such is the case in practical operations, or that it decomposes the sulphide of silver, while the experiments already recorded show conclusively that both the chlorides of copper, under favorable circumstances, do chloridize the argentiferous sulphurets. The experiments, however, would seem to indicate that the action of the chloride of copper was much more intense than that of the sub-chloride.*

---

* Mr. Bowring's very ingenious arguments may be found in Ure's Dictionary of Arts, etc., vol. iii, p. 664. London, 1867. He urges the following considerations against the theory of the formation of chloride of silver and its decomposition by mercury in the patio:

1. Ores containing silver combined with chlorine only, are considered by Mexican miners most difficult of reduction, causing thrice the loss of mercury, and rendering the process much more tedious than those containing sulphides only. The amalgams from chloride ores and from sulphide ores are very different in appearance. The chlorides instantly attack the quicksilver, coating its globules with calomel—whereas sulphides leave it bright, proving, as Mr. Bowring claims, that they are not transformed into chlorides of silver during the process, and then decomposed by the mercury.

2. It is true that a strong solution of the chloride of copper, mixed with a solution of salt, and placed in contact with sulphide of silver, will, after some time, form chloride of silver and sulphide of copper; but the amount of sulphate of copper introduced in the patio process being sometimes less than one ounce and never more than eight ounces, to 70 pounds of water, could not give a sufficiently concentrated solution to permit this reaction.

3. An inspection of the formulæ given in the text shows that, on one hypothesis, sulphur is set free, and on the other, (Bowring's,) sulphuric acid is formed. That the latter is really the case, Mr. Bowring claims on the strength of the following experiment: Rich ore, containing sulphide of silver, is mixed with oxychloride of copper in a solution of common salt, and mercury is added at ordinary temperature. In about an hour the whole of the silver will have become amalgamated, when, after separating all the

The application and modification of the amalgamation process, as practiced in Washoe, has occasioned among experienced mill-men great doubt as to the beneficial results derived from the use of any chemical agents at present mixed with the ore. This doubt is occasioned, or at least strengthened, by the growing custom of late years of decreasing the quantity of salt and sulphate of copper added to the charge without apparently diminishing the product of bullion. Many amalgamators now abstain from the use of both reagents; others add a small quantity of the sulphate of copper, but no salt. In a few instances, the custom is to throw in only a little of the latter, while in many mills the rule is to employ a small amount of both substances, owing to a slight prejudice against the abandonment of "chemicals" altogether.

The action exerted by these two reagents in the pan would appear clearly to indicate that the benefits derived from their use are partly to aid in converting the sulphide into chloride of silver, as in the patio, and partly to decompose such minerals as are but slightly attacked by the mercury. In the Washoe process, however, the large quantity of iron present must tend greatly to produce sub-chloride of copper almost as soon as the chemical agents are thrown into the pulp.

Notwithstanding the importance of common salt and sulphate of copper in the patio, and, under certain conditions, in the pan, their value must be considered as only secondary in the decomposition of a large proportion of the Comstock ores. The advantages derived from their use are shown to be exerted chiefly upon such minerals as blende and galena, which are but slightly attacked by the mercury. But the amounts employed are in most cases too small to effect any very favorable results. On the other hand, if a sufficiently large proportion of the reagents are consumed in the pulp, in order to produce the beneficial returns, it is always at the expense of preserving the necessary purity of the mercury. The quantity of salt deemed necessary by mill-men varies from one-quarter of a pound up to seven or eight pounds per ton. Scarcely any two establishments have the same rule. Its action upon the ore, without sulphate of copper, in producing any marked results may well be doubted. The consumption of the sulphate of copper also depends upon the ideas of the amalgamators, but the amounts do not differ so widely as in the case of the chloride of sodium. It ranges from one-quarter of a pound to three pounds per ton.

The addition of the sulphate without salt is, of late years, a common practice. The opinion among those who work their ore in this way is, that it gives a little better yield than when mercury alone is employed, particularly where the ore indicates the presence of galena in any considerable amount, in which case it is said to quicken the mercury, and render it more energetic. Continued experience appears to determine this fact with a considerable degree of certainty. In working ores containing only a small percentage of lead, the quicksilver very soon becomes dull and inactive, or, as it is technically termed, it sickens, and the yield from the pan is consequently low. Lead is one of the most deleterious metals in destroying the amalgamating energy of mercury, and at the same time is very rapidly absorbed when the two metals are brought into contact. Sulphate of copper possesses, to a certain extent, the property of expelling lead from mercury, copper being amalgamated and sulphate of lead formed at the expense of the sulphuric acid of the copper salt. If a concentrated solution of sulphate of copper be allowed to stand upon lead-amalgam the action takes place quite rapidly, mercury containing lead acting much more energetically upon the copper solution than when perfectly pure. This salt, however, does not appear, under any circumstances, to possess the power of completely driving out the lead. Another advantage derived from the addition of a small quantity of the sulphate of copper is that mercury, under certain conditions, when exposed to the solution, forms a minute amount of copper-amalgam, which causes the metal to act with a somewhat greater intensity in the decomposition of the silver sulphide than when perfectly pure. Iron, as a reducing agent, in the pan process, probably plays an important part in bringing about the favorable results obtained. This may occur in three ways: First, it aids, in a great measure, the decomposition of the chloride of silver; secondly, it reduces the calomel formed during the operation; the chlorine, combining with the iron, goes into solution, and the heavy metal is liberated. In this way it not only prevents a chemical loss of mercury but also serves to keep the surface of that metal bright and clean, which otherwise might be coated with a thin film of sub-chloride, which would greatly destroy its activity; thirdly, it undoubtedly assists directly in the amalgama-

soluble salts by filtration, a test with chloride of barium precipitates sulphate of baryta equivalent in quantity to the sulphur which has become acidified.

Whatever may be the case in the patio process, it seems to me that Bowring's theory does not agree with the facts of the pan process. In this case, the ores of chloride of silver are considered the easiest of reduction; and the best method hitherto discovered for the treatment of refractory ores involves their chlorination preparatory to amalgamation. But the notion that the pan reactions are the same as those of the patio, though quite common, is not necessarily true. One great difference is in the amount of exposure to the air, and this alone would be sufficient to account for the presence of oxychloride of copper in the patio and not in the pan.—R. W. R.

tion, where the two metals are brought into close contact with the easily reducible sulphurets. The successful and continued operations in Washoe, without the aid of any other chemical agents, sufficiently prove this statement. The experiments already cited in treating argentite and iron filings with mercury confirm the fact. Humboldt, in speaking of the amalgamation problem in Mexico, draws attention to this point and remarks upon the rapidity with which amalgamation was secured when the two metals were triturated together with argentite. This action of iron is obtained not only from the constant agitation maintained, which brings the pulp and metal in contact with the sides and bottom of the pan, but also from the amount of iron disseminated, in a fine condition, through the ore, produced by the wear of the stamps, shoes, and dies.

This consumption of metal from the batteries and pans varies very much in the different mills, depending partly upon the details of construction and grinding effects of the pans and partly upon the hardness of the castings employed. The following figures from two mills serve to show the quantity of iron reaching the pulp from this source, per ton of ore worked. The quantity of ore treated is sufficiently large to afford a very fair estimate of the metal consumed:

Tons of ore worked.	Loss of iron in batteries. (Pounds per ton of ore.)	Loss of iron in pans. (Pounds per ton of ore.)	Total.
14,000	2.78	9.42	12.20
12,236	2.10	7.14	9.24

The fine iron coming to the ore in this way is very considerable in proportion to the other minerals present. If ten pounds per ton are added from this source it is equal to one-half of one per cent. In the Kentuck ore, of which an analysis has been given, there is, including the iron from the batteries, less than 2½ per cent. of ore-bearing minerals present.

Mercury and iron, under the proper conditions, undoubtedly are the principal agents in the extraction of the precious metals by the Washoe method. The results depend, however, in a great measure, upon the mechanical treatments employed to reduce the ore to an exceedingly fine state of division, and to maintain, with the proper degree of consistency, a constant agitation of the entire mass; the essential conditions of the amalgamation being that the mercury should be thoroughly incorporated in the pulp, and every particle of the reducible minerals brought in direct contact and triturated with the metal, in the manner so well accomplished by the friction and grinding action of the pan. The mercury should also at all times retain a bright, clean surface, free from any film of metallic salts, such as sub-chloride of mercury or sulphate of lead, and any coating of oil or grease. The slightest tarnish appears to retard very greatly the activity of the metal. The iron seems to act as an electro-chemical agent; the immediate contact of the two metals, aided by heat and friction, causing a local electric current, which renders the amalgamating energy of the mercury much more intense. Mercury, when perfectly pure, does not apparently possess to so great an extent the power of taking up other metals, or of decomposing mineral combinations, as when it holds a minute quantity of some foreign metal in solution. The experience among amalgamators in Mexico is that the yield of gold is increased by the presence of silver; also, that the latter metal is extracted with greater facility if a considerable proportion of the amalgam is already present. This opinion is held by most mill-men in Washoe.

It is stated by some writers upon the question that silver is absorbed with increased activity when copper is employed, and as the former is amalgamated the latter will be expelled. Both iron and copper cause the formation of copper-amalgam. On the other hand, sulphate of copper exhibits a tendency to drive out lead. Karsten mentions the property of this salt to purify the mercury from both zinc and antimony. Any one who has witnessed the intensity which sodium-amalgam exerts cannot fail to have been impressed with the rapidity with which it attacks gold, silver, and silver compounds; yet its application in Washoe, in practical operations, did not give such results as would warrant its general introduction in the process.

Although the presence of a small quantity of several metallic bodies enhances the amalgamating energy of the mercury, yet a slight excess "sickens" it; that is, it loses its fluidity and becomes dull and inactive. The peculiar phenomena attending the mercury, by which both electro-positive and electro-negative metals are absorbed, and the effects which they produce in increasing or neutralizing its action, are very little understood.

The loss in quicksilver during the operation arises from two sources; the one mechanical, the other chemical. The former depends largely upon the manner in which

the final washing from the pulp is conducted; the separation being more or less perfect according to the skill and care with which it is executed. A considerable quantity of the metal, however, is so cut up and ground to such a fine state of division that it is impossible to save it. The chemical loss is occasioned by the formation of the chlorides of mercury, which escape with the tailings.

In the patio the chemical loss is frequently very considerable; the amounts of common salt and magistral employed are large, while, at the same time, there is no reducing agent present to act upon the calomel formed, as is the case in the pan. In the patio the loss is said to increase in proportion to the richness of the ore in the sulphurets of silver, owing to the fact that for every atom of chloride of silver reduced by the mercury a corresponding atom of the latter metal is consumed as sub-chloride.

In the Washoe process the chemical loss would seem to be small in proportion to the entire consumption. This is probably due to the beneficial effects of the iron, which combines with the chlorine of the calomel, setting the quicksilver free.

The more the metal is ground the more it must be cut up, and the greater the difficulty in recovering it. Now, if the consumption of iron is assumed to measure the grinding effect exerted by the pan, the relation between the loss of mercury and that of iron should be, in a certain degree, proportional.

The following table, compiled from the results of several mills, furnishes some interesting details in regard to the loss of mercury:

Part 1 shows that the loss of mercury is independent of the consumption of chemical agents.

Part 2 shows that the loss of mercury is, in some measure, dependent upon the consumption of the iron of the pan.

Tons of ore.	1.				2.	
	Pounds per ton of ore.				Pounds per ton of ore.	
	Salt.	Sulphate of copper.	Sulphuric acid.	Mercury.	Iron.	Mercury.
5,400	....	0.33	0.18	1.54	9.42	1.54
8,605	....	1.74	0.31	1,39	9.70	1.38
4,713	0.23	1.52	....	1.34	9.39	1.38
35,000	9.00	3.00	....	1.33	7.50	1.33
7,523	....	1.38	....	.79	7.14	1.00

The following is the result of an analysis of some artificial crystals of Washoe amalgam:

Mercury	75.04
Silver	24.18
Gold	.77

They have the composition, very closely, of three atoms of mercury to one of silver.

From the foregoing considerations of the principal features of the Washoe process it appears—

That the ore consists chiefly of native gold, native silver, and argentiferous sulphurets, associated with varying proportions of blende and galena.

That the action of chloride of sodium and sulphate of copper in the pan produces chloride of copper.

That the presence of metallic iron necessarily causes the formation of the sub-chloride of copper.

That both the chlorides of copper assist in the reduction of the ore by chloridizing the sulphurets of silver, and in decomposing the sulphurets of lead and zinc.

That sulphate of copper enhances the amalgamating energy of mercury, by causing the formation of a small quantity of copper-amalgam. It also tends to expel the lead.

That notwithstanding the importance of chemical agents, as above indicated, the quantities added to the pulp, in the ordinary practice of Washoe mills, are too small to effect any very beneficial results.

That mercury and iron, aided by heat and friction, are the principal agents in the extraction of the precious metals by the Washoe process.

That the essential conditions in the amalgamation of the gold and silver are that the mercury be kept perfectly bright and pure, in order to produce a direct contact of that metal with the iron and sulphide of silver.

That the consumption of mercury in the Washoe process may be considered chiefly a mechanical, and, only to a limited extent, a chemical loss.

The Washoe process in Owyhee, Idaho.—I am indebted to Mr. John M. Adams, the superintendent of the Owyhee and other mills at Silon City, Idaho, for interesting notes upon certain details of the pan process as practiced by him.

The chemicals employed for different purposes connected with the amalgamation are salt, sulphate of copper, sulphate of iron, sal ammoniac, sulphuric acid, potash, gum catechu and cyanide of potassium, of which sal ammoniac and sulphate of iron are used by some mill-men of the district, but not by Mr. Adams. Chemical action is also due to the quicksilver, the iron pans, the friction of the grinding surfaces, and the heat given by the introduction of steam.

The exact effect of some of the chemicals is a moot question. Mr. Adams, whose scientific training and practical experience entitle his opinion to great respect, speaks substantially as follows concerning the subject, as connected with the Owyhee ores.

He does not think that salt alone chloridizes the ore in the pans, though it exercises a stimulating effect of some kind upon the amalgamation, as he has proved to his own satisfaction by working different charges of the same ore with nothing but quicksilver, and with nothing but salt and quicksilver. He finds, however, that the effect, though decidedly beneficial, is not very strong. I am inclined to infer from these observations that the salt does decompose, and therefore chloridize, certain minerals in the ore, possibly blende and galena, and that these minerals are minor elements of the ore.

Sulphate of copper, when added alone to the quicksilver in the pan, assists the amalgamation. This Mr. Adams explains as follows: the sulphate of copper is decomposed in contact with the iron of the pan, forming sulphate of iron and metallic copper; the latter continues the decomposition of already partially decomposed silver sulphurets in the ore. But this effect does not amount to a complete reduction of the silver sulphurets; which, indeed, cannot be accomplished with either salt or sulphate of copper alone.

These two chemicals together, however, give rise to a strong reducing agent, the sub-chloride of copper. Mr. Adams finds that this substance, employed in the proper proportion and for a sufficient time, will entirely reduce any of the minerals of silver, except those containing antimony, which salt and sulphate of copper, even employed together, fail to attack.

Any effect from sulphate of iron or sal-ammoniac he has failed to discover. Sulphuric acid will, to a certain extent, decompose sulphides of iron and copper, thus freeing some gold; and it attacks in a similar manner argentiferous compounds of iron, lead, and copper which do not contain antimony. Moreover, if kerosene, tar, or machine-grease, gets into the pan with the pulp, sulphuric acid will destroy it, and thus prevent the contamination of the quicksilver, which is detrimental to amalgamation. This acid also serves to keep clean the surface of the iron of the pan, which is thus enabled to exert continuously the reducing action.

Frequently tallow, grease, and candle-ends are brought in the ore from the mines, and pass into the pulp, where, if not counteracted, they will coat the mercury. The use of potash in the pan destroys the grease, and frequently, in drawing a charge into the settler, a thick scum, like soft-soap, will be seen floating on the surface of the liquid, while the quicksilver comes out perfectly clean and as bright as a mirror.

Cyanide of potassium has a beneficial effect in the pan; but its use in adequate quantity is too expensive at present prices. It may be em-

ployed with advantage, however, to clean the quicksilver, or to collect it when floured or granulated. Gum catechu also is a cleansing agent.

The mill process at Owyhee is essentially the Washoe process. In the Owyhee mill the ore is broken in a Blake crusher, and delivered to the stamp-batteries, where it is pulverized with water, and discharged though screens, having 144 holes per square inch, into tanks. In these the pulp settles, and the water passes through other settling-tanks and out of the mill to the slime reservoirs, of which there are five. In these the light slimes are precipitated, to be reconveyed by means of a tramway, bull-wheel, rope, and car, to the mill for further treatment.

The pulp is taken by means of a car from the battery-tanks to the pans. Here it is mixed, ground, and amalgamated for six hours, steam and chemicals being employed to assist the process. From the pans the charge passes into settlers, thence into agitators, thence to Hungerford concentrators and Evans's riffles; and finally, the tailings pass over a string of blanket-sluices. The average yield of this mill, without reckoning the results of the reworking of the slimes, is 92 per cent. of the fire assay. This must certainly be regarded as the most successful application of the Washoe process in the country. The character of the ores no doubt facilitates their economical reduction; but the extraordinary efficiency of the mill is certainly due in large part to well-constructed machinery and to most skillful and faithful superintendence, coupled with constant study of the mechanical and metallurgical problems involved.

Those who find in the supposed imperfections of this or that process an excuse for heavy losses of the precious metals in reducing ores would do well to note such instances as this and profit by the example.

The Washoe process, as practiced by the Meadow Valley Mining Company in Ely District, Nevada, is described in the article upon Lincoln County in this report.

CHAPTER XIV.

CHLORINATION.

The extraction of gold by chlorination was introduced by the celebrated metallurgist, Plattner, a professor in the School of Mines, at Freiberg, Saxony. It is practiced in a few localities in Silesia, Hungary, Transylvania, etc., and is acknowledged to be the most complete method of gold extraction on a large scale. It was first introduced in this country, thirteen years ago, by G. W. Deetken, of Grass Valley, California, a skillful metallurgist, who has added some mechanical improvements to the process, and successfully overcome many difficulties arising in its local application. In the present chapter a general outline of the method will be given. For more detailed information recourse may be had to the work of Mr. Guido Küstel on Concentration and Chlorination, published in 1868 at San Francisco; and for later improvements and particulars not contained in that work, to Mr. Deetken himself, who still resides in Grass Valley, and may be considered the best authority on the subject.

The principle involved is the transformation of metallic gold, by means of chlorine gas, into soluble chloride of gold, (the *aurum potabile* of the alchemists,) which can be dissolved in cold water, and precipitated in the metallic state by sulphate of iron, or as sulphide of gold by sulphureted hydrogen gas. This precipitate may then be filtered, dried, and melted with suitable fluxes, to obtain a regulus of malleable gold.

From this brief statement, it follows that the following conditions are necessary to the success of the process:

1. The gold in the material subjected to the chlorine must be in a metallic state, and accessible to the gas.
2. There must be no other substances in the charge which will unite with free chlorine, since this would occasion a great waste of gas, and a failure in the desired separation of gold from other metals.
3. There must be nothing in the chlorine employed which will attack and render soluble other metals or bases; since this would render the subsequent solution and precipitate impure.
4. There must be no reaction in the mass treated with chlorine which will prematurely precipitate the gold before the final solution is obtained and drawn off.
5. In a word, it is required that all the gold, and, if possible, nothing else, shall be obtained in the final solution. Precipitation and melting then present no special difficulties.

The process naturally divides itself, therefore, into the preparation of the ore for the action of chlorine; the preparation of the chlorine; the chlorination proper; and the lixiviation, precipitation, and melting.

PRELIMINARY TREATMENT OF THE ORE.

Ores, consisting of quartz and free gold, without admixture of other earths or sulphurets, require no further preliminary treatment than reduction to powder. As the material subjected to chlorination has almost invariably been concentrated mechanically beforehand, no appa-

ratus for crushing or concentration is usually connected with chlorination works. In this account it will be assumed that the raw ore has in all cases been finely pulverized.

Ores containing sulphurets or arseniurets are prepared by roasting. That this class must comprise most of the ores treated by chlorination is evident when it is considered that the presence of these compounds is the chief obstacle to successful amalgamation, and that the concentration of the tailings from amalgamating mills is practically a collection of the sulphurets and arseniurets which they contain.

The object of roasting is to convert the base metals into oxides that will not unite with the chlorine, and to leave the gold in a condition suitable for its chlorination. The latter object may be defeated by one of three causes. The gold in the ore may be in coarse particles, which chloridize too slowly for practical economy. For this reason, ore containing coarse gold is not treated by the chlorination process. Again, the gold may be alloyed with silver, the chloride of which is insoluble, and may form a coating upon the particles, preventing the complete chlorination of the gold. Küstel thinks that gold of very low fineness, containing from 40 to 50 per cent. of silver, will probably resist the chlorination, unless it is in the finest state of pulverization. In such a case, as indeed wherever there is silver to be extracted, some modification of the Plattner process, such as the lixiviation with chlorinated brine, must be employed. This will be alluded to hereafter. Finally, it is possible, though perhaps not demonstrated as yet, that other substances, such as oxide of iron, for example, may coat the gold and hinder the action of the chlorine. This evil (if it exists) is remedied by an addition of salt in roasting. I speak with some doubt on this point, though the efficacy of the use of salt in roasting some ores for chlorination is undoubted. But the nature of this benefit may be otherwise explained than by supposing it to consist in the removal of a coating from the gold. If the latter were the case, then, it seems to me, salt would always be necessary in the preliminary roasting; but this is not the case. Experiments in Colorado (see page 346 of my last report) have indicated that a coating is left upon gold in the roasting of auriferous sulphurets, that it is probably oxide of iron, and that it may be removed by the addition of salt toward the end of the roasting;* but while this coating may be sufficient to prevent close contact of gold and quicksilver, and so hinder amalgamation, it does not necessarily follow that it will prevent the action of chlorine gas.

Turning to consider the first object of roasting, the oxidation of the base metals, we find that it must be conducted with great skill and care to insure the success of the subsequent chlorination. The following

* Of the beneficial effect of salt in the roasting of auriferous ores, preliminary to amalgamation, I entertain little doubt. The experiments in Colorado, here referred to, were those of Mr. Brückner, with his roasting-cylinders. They are, perhaps, corroborated by the unexpected results of the first Stetefeldt furnace, erected at the Twin River Mill, Nye County, Nevada, and tested upon silver ores. It was found that the pan amalgamation of the roasted ore yielded a small percentage of gold in the silver bullion, which had not been the case when ordinary reverberatories were used. In this case, however, salt was employed in the reverberatories as well as in the Stetefeldt furnace; and the only explanation I can at present suggest for the difference in results is, that the finely pulverized condition of the ore in the latter, and the complete access afforded the chloridization agents to each particle, effect a complete chloridizing, and allow an action upon fine particles of gold not secured in the ruder reverberatory process. The reverberatories used in chlorination works, however, differ from those in ordinary silver-mills, and the roasting is more careful and thorough. In this case, salt added *in the late stages* of the process may be more likely to act upon the supposed coating of the gold. But its true function under such circumstances is, I think, in its action upon magnesia, lead, and perhaps lime.

conditions are involved, together with others, less important, or less peculiarly characteristic of this process:

1. In all roasting operations a high initial temperature is likely to cause a sintering of the sulphurets, and a formation of matte, which cannot be oxidized without a new pulverization. This evil is particularly to be dreaded when galena is present. A low heat and diligent stirring are therefore required at the beginning of the process.

2. Under these conditions, the sulphur of the sulphurets is set free, combining with the oxygen of the air to sulphurous acid, which escapes in gaseous form, and to sulphuric acid, which unites with the oxidized metals (especially iron) to form sulphates.

3. The sulphate of iron (protoxide) is, as has been already remarked, a precipitant of gold from its chloride solution. Hence its presence in the roasted ore will defeat the object of chlorination and lixiviation; and it is therefore necessary to destroy the sulphates. This is accomplished by gradually increasing the temperature until a point is reached at which these combinations are dissociated. The formation and subsequent decomposition in the charge of arseniates is governed by similar laws.

4. Lime and magnesia, as well as lead, exert an unfavorable influence on the chlorination, after roasting. For some time after the process had been successfully employed in Grass Valley, the concentrated sulphurets from the Eureka mine, in that district, presented a mysterious obstacle to its application. Chlorine was absorbed by them after roasting; but it seemed to be wasted upon some other substance than the gold. Yet the oxidation in the furnaces appeared to be reasonably complete. Mr. Deetken, who was called into consultation, succeeded in overcoming the difficulty, and became the manager of the chlorination works of the company. According to his experiments, it seems probable that lime, magnesia, (and lead oxide?) are attacked by the chlorine, forming hypochlorites, or oxychlorides and chlorides, after the manner of alkalies. Magnesia, at least, undoubtedly shares with the alkaline bases this property of combining with chlorine. The indifference of the ordinary metallic oxides may, perhaps, be less complete than has been usually supposed. In the case of the Eureka sulphurets the troublesome constituent appears to have been magnesia from the gangue or country rock. The cure was the addition of salt toward the close of the roasting, and at high temperature, by which means the magnesia (sulphate?) appears to have been chloridized.

5. The presence of any soluble metallic salts is injurious, since they at once react upon the oxide of iron, and the latter precipitates the gold from its solution before lixiviation.

6. Chemists understand that metallic oxides, which do not readily, or do not at all, react with chlorine to form chlorides, may decompose readily with hydrochloric acid, since the latter contains hydrogen, which satisfies the oxygen of the base. To explain the matter rudely, (and according to the old-school formulas which are still current among metallurgists,) the equation $R\,O+Cl=R\,Cl+O$ represents a reaction which practically does not take place, the affinity of the metal for chlorine not being sufficient to expel free oxygen. But in the reaction expressed by $R\,O+H\,Cl=R\,Cl+H\,O$, the affinity of the metal for chlorine is reënforced by that of hydrogen for oxygen, and the formation of a metallic chloride and of water simultaneously occurs. But this formation of any other soluble chloride than that of gold is to be avoided, because it leads, as I have indicated, to a premature precipitation of gold. Hence,

the chlorine gas employed in this process must be carefully freed from muriatic acid.

7. Muriatic or hydrochloric acid acts injuriously in another way, namely, when by reason of incomplete roasting the charge contains metallic sulphurets. Decomposing these, the acid produces chlorides, setting free sulphureted hydrogen gas, which is a precipitant of gold from its chloride solution.

8. The free chlorine is both annoying and destructive of health. Care should therefore be taken to ventilate the works thoroughly and to protect the workmen as much as possible against the inhalation of the gas.

The roasting is performed, as I have said, in a reverberatory furnace. This kind of furnace derives its name from the fact that the ore treated in it lies upon a hearth, over which is a low arched roof; and the flame from the fuel in the fire-place at one end, passing over a dividing wall called the fire-bridge, "reverberates" along the roof, and is reflected upon the charge. In a muffle-furnace the flame is not allowed to come in contact with the ore, but surrounds and heats the muffle or small oven containing the latter, while the actual oxidation is effected by fresh air introduced from outside. Naturally there is a loss of heat in this form, and the reverberatory, which gives in the case now under discussion equally satisfactory results, is preferred on account of the saving of fuel. The Gerstenhöfer or the Stetefeldt furnace may perhaps hereafter be applied to this use with still greater economy.

Küstel gives several examples, with descriptions and diagrams, illustrating different forms of reverberatories employed. They may be classified as single and double furnaces. The latter has two hearths, one over the other; and the roasting is begun upon the upper and finished upon the lower hearth. The furnace erected by Mr. Deetken at the Eureka works, which appears to be one of the best forms, has the lower hearth placed, not immediately under the upper, but in continuation of it, on a level 7 feet 10 inches lower. The two are connected by a step-flue. The upper hearth is 6 feet wide by 39 long, and has six working-doors on each side. Through these the charge is stirred and pushed along, as desulphurization advances. The lower hearth, immediately next the fire-place, is much shorter. Here the final roasting takes place, with the addition of salt. A draught through the whole is maintained by means of a chimney 25 feet high and 28 inches square in the clear. Mr. Küstel says of this furnace that it requires more room than the ordinary double furnace, but the work of stirring is less tiresome, since the roaster is not obliged to step constantly up and down. Another advantage is the extent of the upper hearth, which receives nine tons of ore without difficulty, whereas the charging of a furnace two (or even three or four) stories high is troublesome if not favored by sloping ground. It takes about twenty hours to finish the roasting of a charge of 2,000 pounds of sulphurets; but by employing a large and long furnace, such as is here described, over ten tons can be treated continuously, the latest charge receiving its preliminary while the earliest receives its final roasting. The capacity of such a furnace appears from the following brief description of the process, nearly as given by Mr. Küstel.

The heat in the lower hearth is always kept bright. One ton is roasted below, and about nine tons are spread on the upper long hearth. Two roasters are constantly at work, mainly at the separate hearths, but together, when required, at either. The ore on the upper hearth is pushed along as the process proceeds, until it arrives at the flue leading

down to the lower hearth.* At this point it contains oxides and sulphates, with a small portion of undecomposed sulphurets. The previous charge on the lower hearth having been withdrawn, the charge nearest the flue (one ton) is pushed down and spread upon the lower hearth. Here at a lively heat, and with active stirring at intervals, the base metals are converted into oxides in about eight hours, and the charge is finally withdrawn into an iron car. As soon as a charge is drawn into the lower hearth, the following charges are moved forward in succession, and space is thus left nearest the chimney, at the remote end of the upper hearth for a new charge of one ton of raw sulphurets. The capacity of the furnace, with two roasters constantly employed, (or four in twenty-four hours, is therefore three tons, while that of an ordinary single reverberatory, employing one man, (or two in twenty-four hours,) is but little more than one ton.

The roasted ore is removed in the iron car to a cooling floor. In Mr. Deetken's Eureka Works this floor is in front of the furnace, and very near, so that the removal can be effected directly.

PREPARATION OF THE CHLORINE.

The chlorine gas is prepared from peroxide of manganese, salt, and sulphuric acid, in a leaden vessel. The proportions for a charge of three tons of roasted sulphurets are given as follows:

	Pounds.
Peroxide of manganese, (pulverized)	30
Common salt, according to quality	30 to 40
Sulphuric acid, 66° B	75
Water	45

The water, salt, and manganese are introduced first into the generator, which is covered with a curved lid, fitting in an annular water-joint. Through this cover two lead pipes communicate with the interior, that is, with the open space above the mixture. One is a safety-tube or funnel-tube, bent twice upon itself and terminating above in a funnel, through which the sulphuric acid is introduced. The other is the pipe conveying the chlorine to the vat. A vertical shaft or rod through the center of the cover carries a pair of arms, with teeth, used by revolution as a stirrer of the charge.

The sulphuric acid is introduced in successive small quantities, as needed to maintain a lively generation of gas. The formula of the reaction is, $MnO_2+NaCl+2SO_3=MnOSO_3+NaOSO_3+Cl$, [or, according to modern chemistry, $(NaCl)_2+(H_2(SO_4))_2+MnO_2=Mn(SO_4)+Na_2(SO_4)+(H_2O)_2+Cl_2$. See Barker's Chemistry, par. 140.] After all the acid has been added, when the action flags, it may be stimulated for a while by a moderate fire under the generator. Instead of the ingredients above named, the chlorine may be produced from one part peroxide of manganese, two parts muriatic acid, and one part sulphuric acid, diluted with one part water.

The gas escaping from the generator is purified of muriatic acid by

* Mr. Küstel says the charge is exposed to the preparatory roasting for about twenty-four hours on the upper hearth; but I cannot understand how this can be the case, since the rate of its advance depends entirely upon the removal of the earlier charges, and this is regulated by the final roasting on the lower hearth. With regard to the latter, he says (section 59, p. 250) a ton can be drawn out every eight hours, that is, three tons in twenty-four hours. As the charges are introduced at the same rate on the upper hearth, it follows that if the upper hearth carries, as he says, nine tons, each of them must remain upon it $9 \times 8 = 72$ hours. It is my impression that the quantity of ore on the upper hearth is not so large as this.

"washing" it through an arrangement almost exactly like a pneumatic trough, by which it passes through a stratum of half or three-quarters of an inch of water. This absorbs the muriatic acid, and a proportion of the chlorine, (about 2½ volumes.) Warm water takes up less chlorine, and even a saturated solution of chlorine will still absorb muriatic acid. From the purifier the gas is conducted to the vats or tanks.

CHLORINATION PROPER.

After the roasted ore has become sufficiently cool it is dampened with 4 or 5 per cent. of water, which, it is claimed, facilitates the mechanical passage and the chemical activity of the chlorine. It is then sifted into the chlorination vat. The sieve used for this purpose need have no more than 7 to 8 meshes per linear inch.

The European authorities say that the vessels used for chlorination must not be of wood or metal, and recommend earthen pots or bottles.* This is troublesome and expensive, compared with the simple treatment in vats employed in this country. The reason for the usual prohibition of wood has been, I presume, the amount of gold solution which it would absorb; but Mr. Deetken has completely overcome this evil by the simple expedient of coating the inside with equal parts of pitch and tar. Thus, instead of small earthen pots, he is enabled to use large tanks, holding several tons of roasted ore. These are circular in form, and possess a false bottom, about 1 inch from the real one. Upon the false bottom, which consists of boards placed about one-eighth of an inch apart, and pierced with half-inch holes from 10 to 12 inches apart, is spread a layer of clean quartz, 1½ to 2 inches thick. Any other indifferent rock will do, but not a rock containing magnesia or lime. This first layer of quartz is coarse; over it smaller pieces are laid, and so on, decreasing in size till a layer of sand covers the whole, forming thus a filter from 4 to 5 inches thick. This filter remains in the vat. Upon it the ore is sifted, when duly prepared for chlorination, and the cover is put on. This is nearly flat, and of wood. It is suspended by a chain attached to its center from above, and can thus be swung to its place promptly. The edge all around is luted with wheaten dough. A small hole in the cover is left open, to allow the escape of air and to serve as a means of observing the moment when the chlorine appears on the top of the ore. When this moment arrives the whole is closed and plugged with dough.

Chlorine is now conducted into the ore and permitted to operate from twelve to eighteen hours. Leakages of gas from the apparatus may be detected by the odor, and by the formation of white fumes when approached with a glass rod previously dipped in ammonia.

The coarser the gold the longer the chlorination. After, as a maximum, eighteen hours, the cover is taken off and water is introduced. Usually, if the process has been effective, free chlorine has passed through the body of the ore, and makes its appearance as a green gas on the surface. When the gold is fine this may take place after twelve hours.

LIXIVIATION AND PRECIPITATION.

When the gas appearing on the surface indicates that the whole mass is permeated with chlorine, the cover is removed, and water is introduced until the surface of the charge is covered. Then a cock at the

* See Crookes and Röhrig's Kerl's Metallurgy, vol. i, p. 637.

bottom, communicating with the space under the false floor, is opened, and the solution is drawn off and conveyed to the precipitation vat. This is a wooden tub or cistern, but without a false bottom. Küstel recommends a rectangular form, with a half-round, somewhat inclined bottom, and a lining of sheet lead. The precipitant employed is a solution of sulphate of the protoxide of iron, (copperas, or green vitriol,) which is usually prepared fresh at the works from wrought iron and sulphuric acid. This part of the process is so simple as not to require detailed description here. The mixture generally remains undisturbed over night, giving the gold precipitate an opportunity to settle. The supernatant liquid is then carefully removed by tapping the tank at successively lower levels, until little is left with the precipitate. The latter is dipped out with care, by means of a dipper or scoop, into a clean porcelain or enameled dish, the final residuum being washed out through the lowest stop-cock of the vat, and the vat is cleansed from adhering particles with a stream of water, in the same manner as precipitates are washed upon filters, or breakers are cleaned of adhering portions of precipitate in the chemist's laboratory.

The gold obtained is in the form of a brown powder or "cement." This is filtered upon paper, and subsequently dried in an iron or porcelain vessel. Finally, it is smelted to a metallic regulus in clay crucibles, a little salt, borax, and nitrate of potash (saltpeter) being used as fluxes.

Küstel gives the following expense of the cost of treatment, for a capacity of three tons daily from a double furnace. His figures refer to Grass Valley in 1867, since which time some items of expense have been reduced in that locality. The results obtained in this table are, however, in my opinion, not far from the present cost, since Mr. Küstel has made no allowance for incidental outlays, which are inevitable. I have added a column, giving estimates (of less authority) for the same items in Arizona, where expenses are much higher:

	California.	Arizona.
Superintendence	$6 00	$6 00
Four roasters, at $3 50	14 00	14 00
Three cords of wood, at $4	12 00	10 00
Thirty pounds manganese, at 6¼ cents	1 87½	3 00
Forty pounds salt, at ¾ cent	30	5 00
Seventy-five pounds sulphuric acid, at 2½ cents	1 87½	15 00
One man at the vats two days, at $3 50	7 00	7 00
Sulphate of iron	60	1 00
Total for three tons	43 65	61 00

Or, in Grass Valley, $14 55 as the average cost per ton, and $20 33 in Arizona.

Much more could be written in detail concerning the manipulations of this process, and the combinations of other kindred processes, such as the plan of Calvert, who recommends the production of "nascent chlorine" in the chlorination tank, instead of the introduction of ready-made chlorine gas; of Roeszner, who employs a salt solution saturated with chlorine; and of Patera and others. Many of these processes are intended to save the silver as well as the gold. But I must refer the reader to the books on the subject for all these matters. None of the processes, save simple chlorination, is, so far as I know, employed in the United States. I have confined myself, therefore, to a brief and general description of what is universally known as the Plattner process.

There is no doubt of the metallurgical perfection of this process. The reasons why it is not more frequently employed in this country are—

1. The cost of treatment per ton, excluding all low-grade ores from profitable reduction by it.

2. The real scarcity, except in one or two mining districts, of ores suitable for chlorination. Even perfectly effective chlorinating works suffer almost everywhere from lack of ore, and scarcely any in the country are run continuously at full capacity. Yet this "full capacity" would require but from one to three tons of ore daily.

3. The lack of metallurgical skill in the construction and operation of furnaces for the preliminary roasting. On this everything depends, and it is perhaps in this department that several failures in Colorado have occurred. It certainly seems strange that the Territory offering apparently most suitable conditions for the process should witness so many failures in it. The works of Cash & Co. at Central City are not here referred to; they are reported to be successful; but the owners are reticent as to their methods and results, and there is consequently nothing certain to be said of them.

Chlorination, in its present form, cannot supersede amalgamation for ordinary milling ores. It can compete with smelting where nothing is to be extracted but gold, (or, by Roeszner's method, gold and silver,) and in any case it is quite likely that the process will be best administered by custom works, receiving the ore from different mines, and running continuously.

But, since the cost of roasting is more than half the total cost, it is possible that improvements in the mechanical means of roasting, such as the introduction of the O'Hara, the Gerstenhöfer, the Brückner, or the Stetefeldt patents, may considerably reduce the expense, and thus enlarge the field of the Plattner chlorination. The capacity of the Stetefeldt and the Gerstenhöfer furnaces is very great, and the evil of a short supply of ore might be aggravated by their employment; but, on the other hand, the reduction of the cost of treatment by a little would increase the amount of ore chlorinated by a great deal.

GOLD REFINING BY CHLORINE GAS.

The following interesting paper, read before the Royal Society of Victoria, by F. B. Miller, F. C. S., Assayer in the Sydney Branch of the Royal Mint, describes a new method of refining gold, which, it is reported, will be tried by the Mint of the United States, Mr. Miller having visited this country for that purpose:

There is no recorded instance of gold having been found in an absolutely pure state. Every natural alloy of gold (or native gold, as it is called by mineralogists) contains more or less silver; and in almost all bullion resulting from the melting of Australian alluvial gold, the portion that is not gold consists chiefly of silver, with only a very small proportion of foreign metals, usually copper and iron, with occasionally a little lead or antimony, and sometimes a trace of tin, iridium, etc. This, however, though true generally, is not always the case with gold obtained from quartz veins by amalgamation, as the mercury occasionally reduces and takes up other metals as well as the gold, which appear in the bullion on melting. The accompanying table will give some idea of the proportion of the precious metals contained in the gold from the various districts of New South Wales, after melting. It will be seen that the most argentiferous is that from Boonoo Boonoo, in the north, containing as much as 34 per cent. of silver. This approaches in composition the gold from the productive Thames district of New Zealand; while the gold from Nerrigundah, in the south, only contains 1.5 per cent. of silver, the remaining 98½ per cent. being gold with a trace of copper:

Table showing the proportion of gold and silver in characteristic samples of gold dust from various localities in New South Wales, (after melting.)

Locality.	Gold in 1,000 parts.	Silver in 1,000 parts.
NORTHERN.		
Boonoo Boonoo	654 to 695	337 to 298
Fairfield	872	121
Timbarra	708 to 898	280 to 97
Peel River	929	67
Rocky River	934 to 962	61 to 33
Nundle	923 to 937	66 to 63
WESTERN.		
Bathurst	827 to 903	164 to 92
Sofala	929 to 933	66 to 63
Tuena	943	54
Ophir	915	82
Tambaroora	943 to 954	54 to 42
Turon	918 to 928	78 to 68
Hargraves	915	83
Windeyer	946 to 959	53 to 37
SOUTHERN.		
Burangong	948	48
Adelong	946 to 951	52 to 45
Braidwood	928 to 934	67 to 62
Emu Creek	971	27
Delegate	971	27
Norrigundah	983	15

An interesting, and as yet unanswered question here arises: Is this argentiferous character in any way connected with the geological structure of the district?

It is a fact, and certainly a very curious one, whether it arises from accidental causes, or whether it may hereafter be traced to peculiarity in the rocks whence the gold of the different districts is derived, that its quality or fineness deteriorates the further north we go; in other words, it contains more silver and less gold.

Thus, the average fineness of Victorian gold is about 23 carats; that is to say, it contains about 96 per cent. of gold and 3¼ of silver, with a ½ per cent. of base metals; while, on passing north, we find the average fineness of New South Wales gold to be only 22 carats 1¾ grain, or to contain 93¼ per cent. of gold and 6 per cent. of silver. On going still further north, to the colony of Queensland, the average fineness is little more than 21 carats, (considerably below standard,) or it contains 87½ per cent. of gold and 12 per cent. of silver; that from Maryborough containing as much as 14 per cent. of silver and only 85 per cent. of gold.

These are averages only. It is not to be supposed that there is a regular and consecutive diminution in fineness with every degree of latitude we go north. There are exceptional localities in the north of this colony, where the gold found is of a high degree of purity, as at Rocky River, where it is over 23 carats fine, or 96 per cent.

Possibly at a future time our geologists may be able to throw some light on these curious facts, and the exceptional cases may then even help in explaining the apparently general rule. The point, however, of principal interest, as far as regards the subject of this paper, consists in the fact that, as the alloy obtained by the gold miner is poorer in gold, it is proportionally richer in silver.

According to the published returns, 6,820,198 ounces of gold have been received for coinage in the Sydney Mint between its establishment, in May, 1855, and December 31, 1868. The average assay of this quantity would be about 943; in other words, it contained 94¼ per cent. of gold, 5 per cent. of silver, and ¾ per cent. of base metals. Allowing an average loss of 2 per cent. in melting the gold dust, there would remain, after smelting, 6,683,795 ounces of gold bullion; and as the silver it contained amounted to 5 per cent. of this quantity, the gross amount of silver in the gold received for coinage was 334,190 ounces; being at the rate of 24,720 ounces per annum.

The average proportional quantity of silver contained in the gold arriving in

Sydney is at present very much greater than that given above, owing to the large amount of silvery gold now being found, especially in the neighboring colony of Queensland, and for the year 1868 was not less than 36,000 ounces, (£9,150,) and was probably (including that in the gold shipped direct as bullion by the banks) nearer 42,000 ounces. Most of the silver thus naturally present in the gold has hitherto been lost to the colony, owing to the expense, in Sydney, of the acids, etc., necessary for its extraction by any of the usual methods of refining, which left little, if any, margin of profit on the operation. It therefore seemed desirable that some easy and economical process should be contrived for refining in Australia, without the aid of costly plant and chemicals.

Twelve months ago a paper of mine, describing a new process for refining and toughening gold by means of chlorine gas, was read before the Chemical Society, London. As, since the publication of that paper, the method of refining therein proposed has been successfully brought into practical operation on a large scale, both here and in New Zeland, and there is a probability that its adoption will, before long, become more general, I lay before the members of this society a somewhat detailed account of the process, and some of its more striking results. I shall, as far as possible, avoid giving the details of the preliminary experiments which lead to the practical application of the process, and which have already been published in the Journal of the Chemical Society; but, in order to render myself intelligible, some repetition of what is therein contained will be necessary.

Most people at all interested in the matter are aware that the ordinary method of separating silver from natural alloys of that metal and gold, is a complicated and expensive process, and that the end is attained by melting the gold with at least two and a half times its own weight of silver, and then again separating, by the action of acids, the silver thus added, and also, at the same time, the small quantity originally contained in the gold, thus leaving as a residue fine gold assaying from 990 to 993; the *rationale* of the operation being this: If the natural alloy were simply placed in the acid, the very large excess of gold in the alloy would completely protect the silver it contained from the action of the acid; but if the gold is melted with a large excess of silver, so that the silver greatly preponderates over the gold in the alloy treated, then the acid is able to exert its solvent action not only on the silver thus added, but also on that originally contained in the gold. To arrive at this end, a complicated and very costly plant is required, besides large quantities of expensive acids; and several days are occupied in the operation. It is evident, then, that if all this complicated process can be avoided, and the silver simply and completely separated in one operation at the time the gold is being melted, a very great saving of time, of material, of plant, and of the interest involved in all these will be effected.

Such an end is attained in the plan now being adopted for effecting this operation. It is well known that chlorine readily enters into combination with almost every known metal, the action in some cases being so violent as to be attended with vivid combustion. Many metals, such as lead, tin, zinc, and antimony, when introduced into this gas, even at ordinary temperatures, combine with it, forming highly volatile chlorides. The two latter, if in a state of fine division, burst into flame on being placed in an atmosphere of chlorine. Copper also exhibits spontaneous combustion under similar circumstances, but the resulting chloride formed is only slightly volatile. Silver immersed in chlorine gas at ordinary temperatures slowly unites with it, forming chloride of silver; but if the gas be passed over it while red-hot, the action is much more energetic, the compound formed being more volatile than the chloride of copper, but much less so than those of lead, tin, zinc, or antimony.

The method of refining now to be described is based upon these facts: It consists simply in passing a current of chlorine gas through the gold *while in a melted state*, which is easily done by thrusting into the molten metal a small clay tube connected with a stone-ware vessel in which chlorine is generated. The chlorine on coming in contact with the silver in the molten alloy at once combines with it, forming chloride of silver, which, being of less specific gravity, rises to the surface of the melted gold, while this latter remains in a purified condition beneath. Chloride of silver has always been considered a somewhat volatile substance, and under circumstances such as those here described, it was naturally supposed that it would either be sublimed in the flue or escape entirely up the chimney; but in practice it is found that the volatility of the chloride is not nearly so great as might have been anticipated, and that if its surface is coated with a layer of fused borax it may be kept melted at a high temperature without any very material loss. The furnace required for the operation is the ordinary 12-inch square gold-melting furnace, the principal points to attend to in its construction being: 1. That the flue should be as near the top as possible, so as to allow of the crucible standing high up in it without being cooled by the draught; and, 2. That the furnace itself should not be too deep, so that when the pot is placed in the fire the bottom of it may not be more than 3 inches above the bars. The covering of the furnace should consist of two fire-tiles, 7½ inches wide and 15 inches long, one of which should have a long slot or hole in its center for the clay chlorine pipes (which

I shall describe presently) to pass through. An iron cover will not answer, as it soon becomes much too hot for convenient working.

The crucibles in which the refinage is performed should be French white fluxing-pots, (creusets de Paris, made by De Ruelle, late Payen, Paris;) ordinary black-lead pots will not answer, owing to the reducing action they exert on the compounds formed. To prevent the infiltration of the very fluid chloride of silver into the pores of the clay pots, (which would otherwise occur, and necessarily entail loss,) they are prepared by filling them with a boiling saturated solution of borax in water, which is allowed to stand in them for ten minutes, and is then poured off, the crucibles being afterward set aside to dry; the borax forms glaze on the inner surface of the crucibles when they become hot in the furnace.

When used for refining these French clay crucibles are placed within black-lead pots, as a precaution against loss, should the former crack, which, however, seldom happens. The crucibles are covered with loosely-fitting lids with the requisite holes bored through them for the passage of the clay chlorine pipes, etc. Ordinary clay tobacco-pipe stems, from 17 to 22 inches long, have been found to answer well for the purpose of passing the chlorine gas through the melted gold. Of late, a pipe made in London to order, $\frac{1}{4}$ inch in diameter, 22 inches long, and $\frac{1}{16}$ inch bore, has been found to answer all requirements. The chlorine generators should consist of the best glazed stone-ware acid jars, capable of holding from ten to fifteen gallons, and furnished with two necks. One of these openings should be stopped with a sound cork (or vulcanized India-rubber plug, if obtainable,) through which should pass tightly two glass tubes—the eduction tube and the safety or pressure tube, the length of the latter being a few inches, and the former 8 or 10 feet, spliced, where necessary, by means of vulcanized India-rubber tubing. The other opening, intended for introducing the oxide of manganese, etc., should be closed with a leaden plug, covered with a short piece of India-rubber tube by way of a washer, and well secured.

Each generator should be charged with a draining layer of small quartz pebbles, down nearly to the bottom of which the pressure tube should extend. On this layer should be placed from 70 to 100 pounds weight of binoxide of manganese in grains about $\frac{1}{4}$-inch cube, sifted from powder; this quantity will be sufficient to effect many refining operations, and will obviate the necessity of repeated dismantling of the apparatus. Each generator should be suspended to about half its height in a galvanized iron water-bath.

The chlorine gas is produced when required by pouring common hydrochloric acid (sp. gr. 1.15) down the safety-tube, the apparatus being warmed by means of gas-burners beneath the water-baths. The gas is conveyed from the generators by means of a leaden pipe fitted with branches to supply the several furnaces, all intermediate connections being formed by means of vulcanized India-rubber tubing which, if screened from the direct radiation from the fire, stands the heat well, even immediately over the furnaces. All joints between the various pipes and India-rubber tubes are easily secured, and rendered perfectly gas-tight with a cement consisting of a thin solution of India-rubber in chloroform.

Screw compression-clamps on the India-rubber tubes give the means of regulating the supply of gas as required, and enable the operator to shut it off entirely as soon as the refining is over. The chlorine then having no means of escape accumulates in the generator, and soon forces all the acid up the safety-tube into a vessel placed above to receive it, and the acid no longer acting on the oxide of manganese, the supply of gas of course ceases.

These generators are very convenient and manageable, and it is questionable whether a gas-holder for the chlorine (even if the practical difficulties in its use could be overcome) would be at all preferable. Two such generators as are here described, and three ordinary gold-melting furnaces, have been found capable of refining daily about 2,000 ounces of gold, containing about 10 per cent. of silver, between 9 a. m. and 2 p. m.

Very many thousand ounces (upwards of 200,000 ounces) have now been refined by this process; and the mode of operation which has in practice been found the most advantageous has been as follows:

The French crucibles, (say, size 17 or 18,) duly prepared with borax, having been placed in the cold furnace, and slowly and carefully heated to dull redness, the gold (from 600 to 700 ounces to each crucible) is introduced, and the fire urged until the metal is melted, the necessary generation of chlorine having meantime been commenced by the introduction of a little hydrochloric acid poured down the safety-tube into the generators.

In order to fill the pots, and avoid the risk of splitting them by the wedging of the ingots at their contracted bottom, the gold for refining is cast in molds of a peculiar form. Two inches from the end, the sides and bottom of the iron ingot-molds converge so as to produce a slipper-shaped ingot, two of which, placed face to face, fit conveniently into the pot.

As soon as the gold is melted, from 2 to 3 ounces of borax in a state of fusion is

poured upon its surface. If the borax is added sooner, it acts too much on the lower part of the pot; and, if thrown in cold, is apt to chill the gold. The clay-pipe which is to convey the chlorine to the bottom of the melted gold is now introduced. (It is necessary to carefully heat the lower portion of this pipe for some ten minutes before introducing it into the molten gold, or it is apt to split.) At the moment of its entering the melted gold, the screw compression-clamp is slightly loosened, so as to allow a small quantity of gas to pass through it, and thus prevent any metal rising and setting in the pipe, which is then gradually lowered to the bottom of the molten gold, where it is kept by means of a few small weights attached to the top. The compression-tap is now quite relaxed, and the gas is heard bubbling up through the melted metal, which it does quietly, and without projection of globules from the pot.

Sufficient hydrochloric acid must be added to the generators, from time to time, to keep up a rapid evolution of chlorine. A rough general rule is to allow one imperial quart of acid of 1.15 specific gravity to every 10 ounces of silver in the alloy operated on. The column of liquid in the safety-tube, acting, as it does, like a barometer, affords a ready means of knowing the pressure in the generator, and of judging of the rate of production of the gas, as well as at once showing by its fall, if anything irregular has occurred—such as a leak or a crack of the chlorine pipe or pot. From 16 to 18 inches in the safety-tube correspond to and balance 1 inch of gold in the refining crucible. When the chlorine is first introduced into the melted gold, a quantity of fumes are seen to pass up from the holes in the crucible-lid; these are not chloride of silver, but the volatile chlorides of some of the baser metals, and they are especially dense when much lead is present in the alloy under treatment, forming a white deposit on any cold substance presented to them. After a time, longer or shorter, according to the impurities in the gold, these fumes cease. So long as any decided quantity of silver is presented in the molten gold, the whole, or nearly the whole, of the chlorine is absorbed, little, if any, appearing to escape, and to be thus wasted; and it is found that the better the supply of chlorine the quicker is the operation.

It is a curious circumstance that, though, in toughening with corrosive sublimate, this substance is only thrown on the surface of the melted gold, yet the whole mass is toughened by its action. It seems essential, in using chlorine, that the gas should pass to the very bottom to effect a complete refinage.

As soon as the operation is nearly over fumes of a darker color than those observed at the commencement make their appearance; and the end of the refinage is indicated by a peculiar flame or luminous vapor of a brownish yellow color, (occasioned by the free and now waste chlorine escaping,) which can be seen on removing a small plug which fits into a hole in the lid of the pot. This, however, of itself, is not a sufficient indication; the process is not complete until this flame imparts to a piece of white tobacco-pipe, or similar substance, when held in it for a moment, a peculiar reddish or brownish yellow stain; so long as it gives any other color, the refinage is unfinished.

When these appearances are observed (usually for gold containing about 10 per cent. of silver in about an hour and a half from the introduction of chlorine) the gas is shut off, and the pots removed from the fire, the white crucible lifted out of the black one, and, together with its contents, allowed to stand seven minutes, until the gold becomes cool enough to set or solidify. The chloride of silver, which remains liquid much longer, is then poured off into iron molds. The crucible is then inverted on an iron table, when the still red-hot gold falls out in the shape of a cone; this is slightly scraped, and then thrown, hissing, into a concentrated solution of common salt to free it from any adherent chloride of silver.

An alloy containing originally 89 per cent. of gold, 10 per cent. of silver, and 1 per cent. of base metals, will yield, on an average, a cake of chloride weighing, with a little adherent borax, 16 ounces for every 100 ounces operated on.

It is necessary very carefully to dry and heat the molds into which the chloride of silver is poured, as the slighest moisture causes the latter to be violently dispersed while red-hot, to the great risk of the bystanders. With ordinary care, this will never happen; but attention is called to the point, as a very deliquescent chloride of iron is apt to form on the molds.

The gold is now fine, and simply requires remelting into ingots.

As before stated, it is found that all these operations can readily be performed, and about 2,000 ounces refined per day in three common melting-furnaces, between 9 a. m. and 2 p. m.; 98 per cent of the gold originally contained in the alloy operated on is then ready for delivery. The other 2 per cent. remains with the chloride of silver, partially in the metallic state, and partly in a state of combination with chlorine, and probably silver.

To free the chloride of silver from this combined gold (that mechanically mixed being eliminated at the same time) it is melted in a boraxed white pot, with the addition of from 8 to 10 per cent. of metallic silver, rolled to about ¼ inch thickness. The chloride of gold is, by this means reduced at the expense of the metallic silver, chloride of silver being formed; while the liberated gold sinks, and melts into a button at the bottom of the pot. As soon as the whole is thoroughly melted, the pot is removed

from the furnace, and allowed to stand about ten minutes, and the still liquid chloride of silver is then poured into large iron molds, so as to form slabs of a convenient thickness for the next operation; that is, its reduction to the metallic state.

After the fusion of the chlorides, a small quantity of a curious spongiform substance adheres to the sides of the crucible used, probably consisting of sub-chloride of silver; but since it always contains a little gold, care has to be taken in pouring off the fluid chlorides to prevent this auriferous sponge from falling out and mixing with them.

The fusion of the chlorides with metallic silver does not remove every trace of gold; but, with proper care, the amount remaining in the silver produced need not exceed three parts in 10,000, or about two grains of gold in every pound (troy) of silver—a quantity too small to pay for further extraction in this colony.

The slabs of chloride of silver are reduced without difficulty by plates of wrought iron or zinc, in the usual way; but my friend and colleague, Dr. Leibius, has contrived a very excellent apparatus for this purpose.

The manager of the Bank of New South Wales has kindly allowed me the use of 500 ounces of Queensland gold to illustrate this paper. This quantity was divided into two nearly equal parts; one portion weighing 248 ounces was left in its original unrefined condition, as seen in the ingot on the table; the other portion weighing 252 ounces was refined in the manner described above, and the resulting bar of fine gold, assaying 995, is placed by the unrefined ingot for comparison, and the silver extracted weighing 38.8 ounces, and assaying 991.1 lies beside it.

Besides the separation and recovery of the silver as above described, another useful end is gained by this process.

A very large proportion of the gold of Australia (more especially that obtained by amalgamation from our quartz-veins) is more or less brittle—an effect generally due to the presence of small quantities of lead or antimony, rendering the bullion quite unfit for coinage or manufacture until it has undergone some process to render it tough.

The methods usually employed for this purpose are either fusion with niter and borax, melting with oxide of copper, or the addition of corrosive sublimate (bichloride of mercury) to the melted gold. The two former of these plans are troublesome, from the corrosive action they exert on the crucibles, and the last (namely, the employment of corrosive sublimate, which is that usually adopted) is most objectionable, from the dense and highly injurious fumes evolved.

In Victoria this is regarded as so serious a matter in a public and sanitary point of view, as to have induced the municipal council of Melbourne to institute an action at law against the Union Bank to compel them to abate the nuisance thus created by their gold-melting establishment. The passage of chlorine-gas through the melted gold is found to effect the complete toughening of the metal by the elimination, as volatile chlorides, of the materials which render it brittle, while the evolution of the deleterious mercurial fumes is avoided.

In the metallurgic treatment of the precious metals some loss is always sustained; but that incurred in the process here described is not found to be excessive.

The average loss of gold in operating hitherto has been found to amount to nineteen parts in every 100,000 of alloy treated, which is considerably less than would be met with in toughening an equal amount of gold with corrosive sublimate in the ordinary manner.

The loss of silver has amounted to 240 parts in every 100,000 of alloy operated on (containing, originally, say 10 per cent. of silver.) There is no doubt that a considerable portion of both these losses would be recovered on further treating the pots and ashes remaining after the operation; and it is found that, as manipulatory skill is acquired, the proportional loss of silver appears to be decreasing. In refining on the large scale, gold containing 10 per cent. of silver, the cost of the operation in Sydney, including labor and the above losses of gold and silver, but exclusive of rent of premises and superintendence, is about five farthings per ounce, but varying with the quantity of silver present in the alloy operated on.

In England, where hydrochloric acid is a waste product of the alkali works, and all apparatus is cheaper, the cost of refining by this method would be proportionally less. The fineness of the gold produced by this process varies from 991 to 997 in 1,000 parts, the average, as found on a refinage of many thousand ounces, being 993.5, or 23 carats, 3¾ grains. The remaining 6½ thousandths are silver; and this compares favorably with any of the previously known practical processes, none of which leave less silver than this in the resulting fine gold.

If the refined gold be subjected to a *re*-refinage by chlorine, the amount of silver left in it can be reduced to 0.2 per cent., just as in the refinage by the ordinary sulphuric acid process, the same result can be obtained by subjecting the refined gold to a further refinage with bisulphate of potash. For practical working, however, this would probably never be attempted.

The silver resulting from this method of refining is tough, but its quality varies somewhat according to the gold originally operated on; if the alloy treated contains

much copper, the greater part of this remains with the resulting silver, but the other metals are nearly all eliminated.

The fineness of the silver hitherto obtained has varied from 918.2 to 992.0 in 1,000 parts, the average being 965.6. Analysis of the silver resulting from the refinage of gold known originally to have contained, amongst the base metals in the alloy, copper, lead, antimony, arsenic, and iron, gave the following result:—

Silver	972.3
Copper	25.0
Gold	2.7
Zinc and iron	traces
	1,000.0

A very extended series of experiments have been made at the Sydney Branch of the the Royal Mint to test the value of this process; and the result has been (as mentioned by the honorable the Colonial Treasurer, in his speech on the Budget, October 14th, 1869) that "active steps are now being taken to bring the system into operation" into that establishment.

I have already, in the paper read before the Chemical Society, acknowledged the obligation I feel under to my brother officers, Mr. Robert Hunt and Dr. Leibius, for their kind help and encouragement in perfecting this process of refining; but my especial thanks are also due to Professor Smith, of the Sydney University, who, in the kindest manner, placed his laboratory at my disposal, to assist me in this matter, and also to Dr. Thompson and Mr. Edward Hill for their valuable and friendly help.

In a paper subsequently read before the same society, Dr. A. Leibius, Assayer to the Sydney Branch of the Royal Mint, described as follows a new apparatus for reducing the chloride of silver, which is employed in connection with the foregoing method.

In the refinage of gold bullion by Miller's new chlorine process, the silver contained in the alloy thus treated is eliminated from the latter in the state of argentic chloride, which, by a subsequent process, is reduced to metallic silver.

This reduction has always been effected in the usual manner, viz, by placing the slabs of fused argentic chloride between plates of wrought iron or zinc, with the addition of acidulated water. Although a perfect reduction to metallic silver has always been achieved, yet it required a considerable amount of time and manipulation, since the thick slabs of fused argentic chloride were, after two or three days, only partially converted into metallic silver, and had to be rearranged in order to expedite their complete reduction. Such manipulations, however, were not only found to be very objectionable on account of the time they required, but more so on account of the very disagreeable work which they caused to the operator. The reduced spongy silver was broken up, by hand, into small pieces, in order to ascertain its complete reduction, and was then boiled in acidulated water to free it from iron or zinc.

It remained, therefore, a desideratum to effect the reduction of the fused masses of argentic chloride in a manner which would at the same time be quicker in its execution, and also obviate the just-alluded-to manipulations.

In 1868, Messrs. De la Rue and Hugo Miller, in London, constructed a galvanic battery, one pole of which consisted of fused argentic chloride the thickness of a goose-quill, the other pole of cylinders of zinc. Adopting this principle, I have endeavored to construct an apparatus which should fulfill the requirements before referred to.

After operating successfully with a small model which allows the reduction of about 250 ounces of argentic chloride in one operation, I have, with slight modifications, constructed an apparatus which will reduce from 1,400 to 1,500 ounces of argentic chloride in twenty-four hours. The apparatus and its dimensions are as follows:

Two thick boards, 15 inches long, are joined together on both ends by three strong battens, so as to form an open box without a bottom, 13 inches long by 14 inches wide, and 15 inches high, (inside measurement.) The two boards forming the length of the box or frame contain seven vertical grooves, ¼ inch wide, and ½ inch deep, at intervals of 1¼ inches from each other. These grooves are cut down to a length of 12 inches, leaving 3 inches of each board forming the legs of the frame.

At the termination of these grooves passes horizontally a narrow slit, ½ inch deep, and along the whole length of each board, into which a strip of metallic silver, ¼ inch wide, and the thickness of about a threepenny-piece, is tightly fixed, projecting on one side of the frame about 18 inches beyond each board.

The seven grooves already alluded to are for holding zinc plates, ¼ inch thick, 14 inches long, and 12 inches high, which rest on both sides on the strips of silver, which, as just described, are jammed horizontally into the sides of the two boards. A connection is thus established between the seven zinc plates and these strips of silver.

The second part of the apparatus consists of a wooden frame, cut out of a solid board 1 inch thick, and supplied with two large iron handles. This frame is the same length as the box holding the zinc plates, but 3 inches narrower. It contains on each side, parallel to the direction of the zinc plates, twelve slits ½ inch long, which hold silver bands ½ inch broad, and the thickness of a threepenny-piece. These silver bands are passed through the slits in the board, so as to form on each side of it six loops, 11½ inches in length, and ⅞ inch wide. The six loops on one side are exactly opposite to those on the other side of the board, at a distance of about 9 inches. They are intended to hold the slabs of argentic chloride, which are 12 inches long, 10 inches high, and about ⅝ inch thick, and are put through these loops lengthwise, projecting on each end about 1 inch beyond the silver bands.

The whole frame holds, as before stated, six of these slabs of argentic chloride, which are placed between the six spaces formed by the seven zinc plates, from which latter they are about ½ inch apart on each side.

The projecting horizontal strips of silver jammed into the sides of the lower frame are then connected with the ends of the silver forming the loops in which the argentic chloride is suspended; and the whole apparatus thus charged is placed in a tub filled with water. After a short time, galvanic action is discernible; the liquid gets gradually warmer, and a strong galvanic current is observed. After about twenty-four hours, the action has nearly ceased, and the whole argentic chloride is found to be completely reduced to metallic silver, which retains in the silver loops the same shape, and outwardly also, nearly the same appearance as when first introduced as argentic chloride. The latter contains always more or less chloride of copper, (eliminated, together with the silver during the operation of refinage by chlorine,) which is reduced together with the chloride of silver; in fact, this soluble chloride of copper helps to act as an exciting liquor for the battery. In the first experiments, a weak solution of salt (chloride of sodium) was used as exciting liquor; but it was found that this could be dispensed with, and only common water used, (the action, however, is, in this case, a little retarded and does not become powerful until about two hours after the battery is set.) By using a part of the resulting liquor from a previous reduction of argentic chloride, and which contains chloride of zinc, it has been found that the galvanic action sets in very rapidly, and accelerates thereby the completion of the reduction.

No acid is used; and, therefore, the amount of zinc used in each reduction has invariably been found to be almost the theoretical quantity required to combine the chlorine of the argentic chloride treated with the metallic zinc, in order to form chloride of zinc.

The quantity of metallic zinc thus used was always from 24 to 25 per cent. of the weight of the argentic chloride reduced.

The reduced silver is boiled out in acidulated water, in order to remove the basic and oxy-chlorides, and finally in pure water, while still suspended in the silver loops. As soon as it is taken off the last boiling, it is immediately ready for the melting pot, since the heat from the boiling water dries the porous mass of silver sufficiently to allow of its immediate melting. The seven zinc plates, when first used, weigh about 140 pounds avoirdupois; the six slabs of argentic chloride, of the dimensions already given, weigh about 1,400 ounces troy.

The zinc plates are used over again, until too thin for that purpose, when they are remelted, and cast into new plates. It has been found that the quantity of zinc used is little, if at all, increased by prolonging the time of connection with the silver plates after the reduction is completed; the whole apparatus, when once set in operation, can therefore be left to itself until it is found convenient to melt the reduced silver.

While this apparatus reduces the argentic chloride much quicker than if the latter is simply placed in contact with zinc or iron plates, it obviates any handling of the argentic chloride from the time the latter has been placed in the silver loops until the reduced silver is ready for the melting-pot—advantages which have been fully appreciated by those who formerly had to resort to tedious and disagreeable manipulations.

CHAPTER XVI.

SMELTING SILVER ORES.

The base metals used for the extraction of silver from its ores by smelting are lead and copper, and the different methods employed may be accordingly classified under the general headings of "extraction by means of lead," and "extraction by means of copper." The latter is as yet not in operation in the United States, and I therefore pass over this subject for the present. The extraction of silver from its ores by means of lead has, on the contrary, assumed such proportions in the West during the last year, that a discussion of this business at the present time seems important. Although it is here impracticable to go into the details of all the different processes in use in various parts of the world, I may still hope to do some good by dwelling especially on those evidently suited best for the conditions under which the extraction of silver by smelting may be most economically carried on in our western mining districts.

Silver extraction by means of lead is classified according to the shape of the furnaces used for the purpose. Thus we have:

I. Smelting in the open hearth;

II. Smelting in reverberatory furnaces; and

III. Smelting in shaft furnaces.

All these processes have one common purpose, the reduction of the lead to the metallic state and the concentration of the metallic silver in it; but the chemical reactions by which this is accomplished often differ greatly, and the efficiency of each method varies with local circumstances. To know therefore the reactions, and to weigh the circumstances in their economical bearings, is the first duty of those who wish to select a process for a particular locality.

I. SMELTING IN THE OPEN HEARTH.

This method is the oldest and simplest; and up to the present day very few improvements have been made in its original features. It has been and is still employed principally in the United States, and in Scotland and the north of England. The process as practiced in the American hearth is distinguished from the method followed in England and Scotland, chiefly by the employment of hot blast in smelting very pure raw ores. The ores smelted in the Scotch hearth must likewise be free from silica, but not necessarily from other gangue. They are prepared for smelting by roasting in reverberatories, and the blast employed in smelting is cold. In both processes, inferior kinds of fuel, such as wood, peat, &c., can be used. The first condition of the economical use of the hearth in smelting lead ores or a mixture of these with silver ores is therefore purity of ore, especially absence of silica and of foreign sulphureted metals. The ore ought to be in the form of pieces, not crushed. If brought to the smelting-works in the latter condition, it ought to be agglomerated in reverberatories before it is smelted in the hearth, but if this has to be done it would be really more economical to finish the smelting process also in the reverberatory.

The above conditions being primarily requisite for successful smelting in the hearth, and a large loss of both lead and silver by volatilization being certain, unless a very extensive and costly system of condensing

chambers or canals is connected with the work, it is evident that, for these reasons alone, (though others might be adduced,) this method cannot come into use economically in the western mining districts. The ores there, though often rich in silver, are rarely free from siliceous gangue, foreign sulphurets, and antimoniurets; and dressing is prevented in some localities by the scarcity of water, and in nearly all of them at present by the high price of labor. Besides, it is extremely difficult to dress rich silver ores without incurring an enormous loss of the precious metal.

It is therefore useless at the present time to dwell upon the process of smelting argentiferous lead ores in the open hearth; and I refer those who may wish to inform themselves more fully on this head to the excellent metallurgy of Professor Kerl, which has of late been made accessible to American readers by the translation of Messrs. Crookes and Roehrig.

II. SMELTING IN REVERBERATORY FURNACES.

The application of the reverberatory furnace to lead smelting is limited by many conditions similar to those enumerated in the preceding paragraph.

There are two processes in use, which are executed in the reverberatory: the roasting and reducing, and the roasting and precipitating process. Foremost as a condition for the economical employment of the roasting and reducing process is the absence, to a certain extent, of siliceous or argillaceous gangue. Whenever the ore contains more than 4 per cent. of these substances, or less than 58 per cent. of lead, this process cannot be executed satisfactorily any longer, because silicate of lead is formed, which is hard to reduce. Moreover the process permits the presence of lime, heavy spar, zincblende, and other foreign sulphurets in small quantities only.

An important drawback in the employment of the reverberatory processes is also the proportionately large quantity of fuel required, and in this country the item of labor, which is larger in proportion to the production than in shaft-furnace smelting. The loss of copper and the deterioration of the lead by the same metal is another objection.

As mentioned above, there are two reverberatory processes in use, the roasting and reducing, and the roasting and precipitating process. These are again carried out in various localities in a somewhat different manner, the deviations consisting principally in a slower or quicker roasting and reducing, or the employment of a lower or higher temperature.

Roasting and reducing processes.

Carinthian process.—It is the object of this process* to accomplish, at the lowest possible temperature, the reduction of a maximum percentage of very pure lead and the formation of a poor slag, which may be thrown away; but this is only possible with very pure ores, and involves, moreover, a small production, as well as a great expenditure of time, fuel, and labor. Success is, therefore, the more probable, the purer the ores and the cheaper fuel and labor. The process consists in a roasting of the galena at a gradually increasing temperature. During the first period oxide of lead and sulphate of lead are formed in sufficient quantity to make a reduction of the larger part of the lead to the metallic state possible by their action on undecomposed galena in the

* Kerl's Hüttenkunde, vol. ii, p. 51.

second period. To facilitate the second reaction, the temperature is increased and the ore is frequently turned. The following are the reactions: $PbS + 2\,PbO = 3\,Pb + SO_2$ and $PbS + PbO,SO_3 = 2\,Pb + 2SO_2$. Part of the galena is changed to sub-sulphide of lead, Pb_2S, which is also reduced to metallic lead by the oxides formed in the furnace.* To lessen the loss of lead by volatilization, the metal reduced first at low temperature is allowed to run immediately down the inclined floor, and out of the furnace. It is of great purity. By a continued stirring and turning of the charge the opportunity to oxidize is given to new particles of galena, and by the reaction of the oxides on the sulphides more metal is continually reduced. Thus the galena is more and more decomposed until finally a point is reached, when the charge consists, for the greatest part, of oxide and sulphate of lead, together with small quantities of oxy-sulphuret of lead, a mixture, from which no more metal is reduced. Then the third period commences, that of the "lead-pressing," *i. e.*, the working of the remaining doughy mass at a higher temperature after mixing small coal with it. Hereby the free oxide of lead, and that contained in the oxy-sulphuret, are reduced, and the sulphide of lead freed from the latter, as well as that now formed from the sulphate, is changed by an excess of oxide into metallic lead, so that at last a proportionally small quantity of slag, poor in lead, remains in the furnace. When, however, galena rich in silver is worked, the slags retain a great deal of that metal on account of the sulphur contained in them, and the great affinity of silver for it. It is thus clear that only ores containing little silver should be worked by this process.

The lead obtained in the last period of the process, at a high temperature, is less pure than that reduced in the earlier period, because other oxides of metals, which are usually present, are easier reduced in a high temperature. In order to refine this impure lead it is remelted at a low temperature in the reverberatory.

The following remarks on the Carinthian process are from an article by Professor M. L. Gruner, of Paris, republished in the Berg und Hüttenmännische Zeitung:

Ores containing little blende and carbonate of lime are treated at a slowly-increasing temperature, and a very pure lead is obtained, while a maximum yield is secured; but the amount of fuel used is very large. The lower the percentage of metal in the ore the larger the loss of lead. While with ores containing 82 per cent. the smelters are permitted to lose 2 per cent., the loss from ores containing 58 per cent. is often 14 per cent. of the metal.

The Carinthian process is especially characterized by its long duration, (210 kilograms, 462.96 pounds avoirdupois, of ore are smelted in ten to twelve hours,) which is principally caused by the feature that the air can only get in contact with the ore by passing through the grate. For this reason the use of wood is more favorable than that of coal. In other smelting-works, as, for instance, at Nouvelle Montagne, near Engis, in Belgium, where stone-coal is used as fuel, air is therefore permitted to enter the smelting-room through canals lying in the fire-bridge along its entire length. It would be a decided improvement on the Carinthian process if the so-called period of pressing were shortened to two or three operations, and the remaining slag were then smelted in shaft-furnaces. This is done at Nouvelle Montagne. Charges of from 550 to 600 kilograms, equal 1212.5 to 1322.7 pounds avoirdupois, are treated in a reverberatory heated with stone-coal, which has a sump under the flue for the

* Plattner, Berg und Hüttenmännische Zeitung, 1854, p. 22.

reception of the lead. At the end of the "stirring" period some stone-coal is mixed with the rich remaining ore; its contents in lead are then reduced to 25 to 30 per cent., and the reduction of the remainder is effected in a shaft-furnace. The ore is spread in a reverberatory in a deeper layer than in other works, and by virtue of the higher temperature the process is finished in less time. To save fuel, double furnaces, (with two hearths, one above the other,) have been tried in Carinthia, but they have not been permanently introduced, because the work was inconvenient, and repairs became frequently necessary. It would have been better to build the hearths side by side on different levels, and to connect the lower one, to which the grate is attached, with the upper one opposite the grate by a side-canal, opposite the entrance of which the upper one should have its working-door. On the upper hearth, which should have a slightly-inclined floor, the roasting would be done, while the lower one would be destined for the periods of "stirring" and "pressing." The transfer of the ore from the upper to the lower hearth would have to be effected by a door, which could be closed at will, located opposite the connecting canal on the upper hearth. Such an arrangement would have been preferable to the return to the old furnace, especially if the rich remaining slag taken out after a shortened "pressing" period, had been smelted in a shaft-furnace.

The French process.—This process* is based on the fact that galena, when roasted for a long time at a low and gradually-increasing temperature, is principally changed into sulphate of lead and less into oxide; and that if at a certain period the roasting is interrupted while there is yet some undecomposed galena present with a preponderating mass of sulphate, and the temperature is then increased, without reaching the smelting point, the constituents of the charge decompose each other in such a way that, with but a trifling reduction of metal, oxide of lead is principally formed, while sulphurous acid escapes. The oxide of lead is then easily reduced by treating it with charcoal.

$$PbS + 3PbO,SO_3 = 4PbO + 4SO_2$$
$$4PbO + 4C = 4Pb + 4CO.$$

If, besides the oxide of lead, sulphate should be present it also will be decomposed by the charcoal. According to Gay-Lussac†, when an excess of carbon is present, the sulphate is changed into sulphide of lead while carbonic acid escapes. When equal equivalents of sulphate and carbon are present at a low temperature, carbonic acid is developed and only half of the sulphate of lead is changed into sulphide ($2PbO,SO_3 + 2C = PbO,SO_3 + PbS + 2CO_2$). When the temperature is increased to a glowing heat, the sulphate and sulphide of lead mutually react so that metallic lead and sulphurous acid result. When two equivalents of carbon are brought together with four equivalents of sulphate of lead one equivalent of sulphide is first originated at a moderate glowing heat, ($4PbO,SO_3 + 2C = 3PbO,SO_3 + PbS + 2CO_2$,) which at an increased temperature is changed by the action of the three equivalents of sulphate of lead into sulphurous acid and oxide of lead, ($3PbO,SO_3 + PbS = 4PbO + 4SO_2$).

This process was originated and for some time operated at Albertsville and Poullaouen, in Brittany, and is at present yet in use in several other European establishments. By it ores can be worked which contain some silica, because at the low temperature used in roasting, a silicate of lead is not so easily formed. But this is no longer true when the contents of silica exceed five per cent. In that case much lead passes

* Kerl's Hüttenkunde, vol. ii, page 78.
† Erdmann's Journal für praktische Chemie, xi, 68.

into the slag. A percentage of zinc-blende in the ore acts favorably because the zinc forms with the silica a stiff slag which prevents sintering. As in the Carinthian process, the ore is exhausted as much as possible in the last or hottest period; but this occasions a loss of lead, as well as an impurer product, so that smelting of the residue in the shaft-furnace would be more advantageous. Comparing the capacity of charge of the Carinthian furnace with that of the French, shows the latter to have a smaller production, a charge of 1,200 to 1,300 kilograms, (2645.5 to 2866 pounds avoirdupois,) in a hearth with sump from 4 to 5 meters square, consuming fifteen to sixteen hours. The reverberatory being larger than the Carinthian, somewhat less fuel is used, but this advantage disappears if double furnaces are employed in the latter process.

The English process.—The principal object of the English modification of the reverberatory process is to reach the greatest possible production; and therefore larger furnaces with three working-doors on each side, stone-coal as fuel, and higher temperatures are employed. This causes a copious formation of oxysulphuret of lead, and especially if silica is present, even in very small quantities, much rich slag remains in the last period, from which the lead and silver have to be extracted in a subsequent smelting in a shaft-furnace. On account of the high temperature employed in the reverberatory, a great deal of lead and silver is volatilized and much of this is lost, although very extensive systems of condensation chambers are attached to the furnaces. If carbonate of lime is present in ores rich in silver, they may be smelted by this process without serious loss, as the presence of the lime prevents the passage of silver into the slags by decomposing the sulphide, and permitting the metallic lead to take up the silver. If it is not present, burned lime is added during the process. Professor Kerl (Hüttenkunde, vol. 2, page 62,) gives the following theory in regard to the reactions in this process:

The normal proceeding consists in roasting considerable quantities of galena at a quickly-increasing temperature, in less time than in the Carinthian process, so that in proportion to the undecomposed galena the quantity of oxides formed is less than in the method just mentioned. If the charge, when in this condition, is exposed to a still higher temperature, metallic lead and subsulphide of lead are formed by the action of the oxides on the sulphides: $2PbS+PbO,SO_3=Pb+Pb_2S+2SO_3$. If the temperature is decreased when no more lead results, the subsulphide of lead, (containing 92.8 per cent. of lead, and 7.2 per cent. of sulphur,) which is homogeneous at a high temperature, but not when at a heat when the mass becomes doughy, is decomposed into sulphide of lead and metallic lead. If, during this cooling, air is permitted to enter the furnace, a part of the sulphide of lead is oxidized, and in a subsequent higher temperature more metallic lead is reduced. The process aims to extract as much lead as possible by repeating these reactions several times; but a point is finally reached where the increased temperature causes the whole mass to melt, and then oxysulphuret is formed, which requires a repeated addition of lime and access of air to make its decomposition possible. When by this last resort no more lead can be extracted, the residue must be smelted in a shaft-furnace.

The consumption of fuel in the English process is very large, surpassing even that in the Carinthian furnace; the cost of labor is proportionally less, but there is a larger loss of lead, by reason of the high temperature employed. The process would be far more economical if the first roasting were conducted slowly and at a very low heat.

After comparing the three roasting and reducing reverberatory processes above described, Professor M. L. Gruner gives the following resumé:

It is clear that the form of the reverberatory has less influence on the success of the process than the mode of working. If, in any of the furnaces, the work is conducted quickly and at too high a temperature, the losses are large; but if the roasting is conducted slowly, at a low red-heat, and the temperature is increased in the second period, just when the correct proportion of sulphuretted and oxidized matter has been reached, the most complete extraction of the lead and silver is secured; and this can be accomplished in any of the reverberatories in use in either of the three processes. It is most advisable to extract the lead from the ore in the reverberatory to within 35 to 40 per cent., and for this purpose the large English reverberatories are more economical than the small Carinthian. A number of working-doors on the two long sides of the furnace is advantageous; but the arrangement of two fireplaces, as in the Belgian modification of the English furnace, is not advisable, because the temperature will thereby too easily transgress the proper limits. A sump for the reception of the lead inside the furnace is best placed in the coolest place. The different furnaces can work up the following quantities of ore, containing from 70 to 80 per cent. of lead, during the year, (three hundred working days:)

	Tons.
Common single Carinthian furnace....................	150
Single Carinthian furnace with air-canals in the fire-bridge..	350 to 400
French double furnace............................	1,000 to 1,200
English furnace....................................	1,000 to 1,400

2. *Roasting and precipitating furnaces.*—There are two processes of this kind. The one, as practiced in Vienne, France, is based on the fact that iron and galena, when mixed and exposed quickly in a reverberatory to such a heat that the mass begins to sinter, and kept for some time at that temperature with continual stirring, react, so that the iron gradually disappears by taking up the sulphur from the galena and forming a matte, while the greater part of the lead remains in a metallic state. If this mass is then smelted by increasing the heat, and permitted to run into a sump, the different constituents separate themselves by their specific gravity, the lead going to the bottom, while the matte, which contains, besides the iron, other metals and some lead, remains on top of the lead and below the slag. The lead contains, nearly always, some metallic iron, which must be removed by a slow remelting. The matte and slag, if not argentiferous, are thrown away, as the first generally contains not more than from 6 to 12, and the latter from 4 to 6 per cent. of lead, which would not pay for extraction by a separate process. If silver ores are smelted by this process, by far the most of the silver will follow the sulphur into the matte, from which it will have to be extracted by further and expensive treatment. For this reason the method is not adapted for the western mining districts, to say nothing of the impracticability of obtaining metallic iron, of which often 35 per cent. is required. It is true that very pure iron ores, together with charcoal, may replace the metallic iron, but even these cannot be cheaply obtained in the necessary purity in most localities.

In the second process it is intended to save metallic iron; and the charge is therefore first roasted alone at a low temperature, so that the galena is as perfectly as possible changed into oxide and sulphate of lead. One half per cent. of coal dust and 12 per cent. of quartz are then

added, and the whole is quickly heated to a cherry red. In this stage of the process the oxide of lead is reduced and the sulphuric acid is partly driven off as sulphurous acid by the action of the coal, and partly expelled by the silica, which takes its place, forming silicate of lead. After the ebullition of the charge has ceased, about 10 per cent. of metallic iron is added and another heat is given, by which the lead is set free, while the iron goes into the slag as a silicate. If the ores subjected to this treatment contain silver, very little of this will pass into the slag when the process is properly managed, because there are mostly oxides present; but there is always a considerable loss of lead in the slag. It is of course very important in this method to get the correct proportions of silica and iron, which are to be added. As we cannot have the process entirely in our power, this is always difficult.

This process is on account of the quick returns which it gives, adapted for use in this country, for smelting silver ores in localities where iron, iron ores, or basic iron slags can be had at a small cost. The process executed in Newark, New Jersey, is identical with it in principle, though it differs slightly in some details. For use in the West, however, the blast-furnace process is far superior to it in all districts now under development.

III. SMELTING IN BLAST FURNACES.

The blast furnace is the best adapted for the smelting of the rich argentiferous lead ores, or of mixtures of lead ores with silver ores in our western mining districts. These ores carry usually considerable quantities of earthy matter and silica, besides the various combinations of metals other than lead and silver. For this reason alone they are not well suited for any of the reverberatory processes. But in addition the blast-furnace process requires less fuel and labor in proportion to the yield. It is true, the volatilization of lead is somewhat greater in the blast-furnace than in the reverberatory; but this may be partly avoided by a proper shape and height of the furnace; and by far the largest percentage of the volatilized lead and silver may be caught in properly-constructed systems of condensing chambers, especially when showers of water are used to cool the fumes.

Galena ores containing little silver, and no other metals, but much earthy gangue are usually subjected to the process known as the precipitation process, those containing much silver, and besides the above substances a large percentage of foreign sulphurets, arseniurets, etc., to the roasting and reducing process. In the latter, a precipitating action is also often introduced either by oxides of iron already in the charge, or by a small addition of materials containing them. For the latter process, the western ores are eminently fitted.

The furnaces used heretofore, vary greatly in shape, and their relative merits have been often discussed by metallurgical writers. Suffice it to say, that the Rachette furnace and the Piltz furnace, (both described in the remarks on Eureka District, Nevada, in a former chapter of this report,) are now conceded on all sides to be the best. They have the largest capacity, and are the most economical in regard to fuel and labor, while the loss of lead in the slag is exceedingly small. In the latest modification of the Piltz furnace, as introduced lately in Clausthal, Germany, the slag contains only ½ per cent. of lead, while formerly from 4 to 6 per cent. was not uncommon. The loss by volatilization is also greatly reduced. This is partly due to the manner of charging, and partly to the shape of the furnace.

A very important improvement has been lately added to the Piltz furnace at Eureka, by Messrs. Keyes and Arents, the superintendent and the metallurgist of the Eureka Consolidated Company, which increases considerably the already astonishing results obtained with this shaft-furnace. At the same time this improvement can be added with only slight modifications to all kinds of shaft-furnaces used for lead or copper-matte smelting; and its introduction is, therefore, of great importance to metallurgists and owners of smelting-works. I speak of the automatic tapping apparatus now in use at the above-named works, which consists simply in a pipe, introduced in the side of the furnace, at the bottom of the crucible, from which it slants upward, ending in a kettle, the upper rim of which is at a level with the height of the lead bath in the furnace when the crucible is filled. It is claimed, and proved by the actual working of this method of tapping, that

1. The furnace runs more regularly.
2. The lead obtained is purer.
3. "Sows" are prevented.
4. The work of the smelters is lightened.

These results agree entirely with the theories bearing on the subject, as I shall show, and a fifth beneficial result might be added, namely, saving of fuel.

When the usual method of tapping a lead furnace is followed, the blast is stopped and the tap-hole in the bottom of the crucible is opened, (sometimes with great difficulty, when metal has cooled in it at a former tapping.) The lead, matte, and slag run out into the kettle, the hole is stopped again with clay or a mixture of clay and coal-dust called "stübbe," and the blast is turned on and smelting resumed. With the cleaning of the crucible, building up of fore-hearth, etc., this part of the smelting often takes considerable time, and the temperature in the furnace is so reduced that much fuel is burned to make up the lost heat. Irregularities in the running of the furnace are frequently directly traceable to this cause, and the first commencement of the formation of "sows" occurs also in nearly all cases during the stoppages, when the small doughy masses of reduced metallic iron have an opportunity to stick to the bottom of the crucible, which is no longer protected by a liquid mass. It is well known to every metallurgist that when the foundation is once laid for a "sow" it is extremely difficult to prevent its rapid "growth;" and even if the larger parts are broken or chiseled out at every tapping, the iron will continually gain on the smelter.

By the employment of the automatic tap the first formation of "sows" is evidently prevented. Even if there be much iron from the charge reduced to the metallic state, the lumps will not come in contact with the bottom, but will always swim on the lead-bath. Being here exposed to the oxidizing influence of the blast, they will be carried into the slag.

It need scarcely be remarked that the arrangement for tapping is a continuous one, and that it carries the molten lead out from the *bottom* of the blast furnace as fast as the metal is reduced inside. At the same time the lead smelted from the charge above remains in the crucible long enough to give the molten ingredients the required time to react upon each other and separate according to specific gravity.

The lead obtained by this apparatus must be purer than ordinary tappings, because it is taken from the bottom of the crucible, where the purest (heaviest) metal gathers, and because foreign metals, as iron, zinc, and antimony are mostly oxidized and slagged before they are alloyed with the lead.

The work of the smelters is of course considerably lightened, because,

in addition to the tapping, the hard work of removing "sows," loosening the charge in the crucible after tapping, etc., is dispensed with. The invention is, as far as I can judge at present, of the first importance for lead and copper smelting, and its benefits to those branches of metallurgy are promising to be as great as those of the Luermann cinder-block have already proved themselves to the iron interest.

1. *The precipitation process.*

This process is the simplest lead-smelting method in use. It is based on the greater affinity of the sulphur for iron than for lead; and, with ores containing only galena and quartzose or argillaceous gangue it can be carried out according to strictly stoichiometrical principles. But when foreign sulphurets are present it becomes less advantageous. The presence of those of copper, antimony, arsenic, etc., is especially undesirable, because these are also acted upon by the iron, and the portions reduced to metal deteriorate the lead, while the sulphurets go into the matte, which, besides much lead, carries the greater part of the silver, if silver be present, with it, thus necessitating further processes for its extraction. For these reasons, and the high price of metallic iron, it is in use at the present time in few localities only, the smelting works in the Upper Hartz Mountains, which work ores containing a high percent of lead, little copper, and silver, and quartzose gangue, being the principal representatives of the kind.

For introduction in the West, where the main object of smelting is the extraction of the silver from the rich ores, while the base metals are of little value, the process is not at all adapted at present.

2. *The roasting and reduction (and precipitation) process.*

This method is eminently adapted to the treatment of ores rich in silver, comparatively poor in lead, and containing various foreign sulphurets, combinations of arsenic and antimony, and earthy and quartzose gangue. Its main advantage consists in a nearly perfect extraction of the silver in the first smelting, because inconsiderable quantities only of matte are formed; but considerably more fuel is needed than in the foregoing process, on account of the roasting; the contents of silica cause often a loss of lead in the slag; and when copper is present in the ore it is lost, if the roasting has been carried out sufficiently to guard against a loss of silver by the formation of matte.

The process consists in a roasting, (the purpose of which is to change the sulphides as much as possible into oxides and to volatilize a part of such deleterious substances as antimony, arsenic, and zinc,) and a subsequent reducing smelting. In the latter it is intended to reduce the oxides of lead and silver; to decompose, by means of iron, either added or reduced from the oxide in the charge, the sulphides of lead and silver which may not have been oxidized during the roasting, and to carry the earthy and quartzose substances into the slag.

This process is at present carried out in an imperfect manner in Eureka District, Nevada. The ores there are mostly carbonates, but a sufficient amount of sulphide of lead and arseniate of iron is present tó cause the formation of a considerable proportion of matte and speiss, which are at present not subjected to further treatment, and hence occasion the loss of much silver and lead. To guard against this the ore should be first roasted at a low heat with an addition of small coal, in order to remove the greater part of the sulphur and arsenic, and then a heat

sufficient for sintering should be given. There is usually quartz enough present in the ores (and whenever this is not the case it should be added) to permit the formation of silicate of lead, from which the metal can easily be removed during the subsequent smelting by a slight addition of iron ores, basic slags containing much iron, etc., as the ores themselves contain considerable quantities of iron. Even if this method is not followed while the preponderance of carbonates of lead in the mines continues, it will certainly have to be introduced as soon as, with increasing depth in the mines, undecomposed sulphurets, arseniurets, etc., are reached.

The principal and latest innovations and improvements in the roasting, reduction, and precipitation process are introduced in Pise, France, and in Freiberg, Saxony. The methods of both these localities have been described by Professor M. L. Gruner, and I insert here a translation of his articles, which are of the highest value for the metallurgist.

Smelting-works at Pise.—At these works ores from Pallières (galena with quartz and sulphurets of iron) and from Sardinia, which are bought up at Marseilles, are smelted. The roasting is carried out in reverberatories, 8 to 12 meters* in length and 2 meters in width, which have doors on one of the long sides only. The roasting is conducted very carefully and completely, without raising the temperature high enough for melting, (slagging). The smelting was formerly done in Castilian furnaces with 3 to 4 tuyères, similar to those of Pont-gibaud, Biache St. Waast, etc., but lately the director of the works, M. Barru, has improved the furnaces in an important manner by making them higher, replacing the fire-proof material in the regions of the tuyères with iron plates cooled with water, and by inserting a charging funnel, closed above, into the top of the furnace.

The furnace rests on a large foundation, held together by a cast-iron ring, in the middle of which the stübbe-sump, 0.90 meters in depth and 1.9 meters in diameter, is located. On the foundation a ring of fire-proof brick is laid, on which stand four curved cast-iron plates, 0.80 meters high, inclosing an interior space 1.15 to 1.20 meters in diameter. These, when properly connected, form the cylindrical wall of the furnace in the smelting-zone. In order to facilitate a change in the height of the tuyères, when necessary, these plates are not directly connected with each other, four pillars, 0.25 meters in length and 0.22 meters thick, intervening between them. In the third one of these, 0.25 meters above the foundation, the tuyères are inserted, and in the base of the fourth the tap-hole is located. Around the outer circumference the plates are connected by clamps, for the purpose of holding the pillars between them and of supporting the upper portion of the furnace. Around the outer surface run three small horizontal troughs of cast iron, which are constantly kept full of water. This runs vertically along the plates, from one trough to the other, and the portion not evaporated is gathered in a reservoir at the foot of the plates. Four to five thousand liters of water are used in twenty-four hours. The upper part of the furnace consists of fire-proof material, which rests on a projection held by the plates.

This part of the furnace is 1.80 meters wide. Higher up follows a simple iron cylinder, the elongation of the iron mantle, which is lined with fire-brick. The entire height of the furnace above the foundation is 3.25 meters. At this height the top is closed by a horizontal iron plate, in the middle of which a sheet-iron cylinder, 1 meter high and of

* 1 meter=39.38 inches; 1 liter=0.88 quart; 1 gram=15.433 troy grains; 1 kilogram=2.204 pounds avoirdupois.

the diameter of the shaft, is inserted. It is open at the lower end, and can be closed on top by a door. At the side, near the top of the furnace, the fumes pass through a flue 0.25 meters wide, into the condensation chambers, which are 470 meters long, and contain 1,860 cubic meters. They are connected with a chimney 40 to 50 meters in height, which communicates also with the roasting furnaces. The furnace has two tuyères, of 0.05 meters diameter, and the blast has a pressure of 0.03 to 0.04 meters. Before putting the furnace in operation the inside of the iron plates is covered with a layer of gypsum, 0.02 meters thick; but as soon as smelting has commenced this falls off in pieces, and in its place a thin layer of slag, or regenerated galena, is caused to adhere to the plates by the cooling effect of the water. In this state the furnace runs from two to three months, and no repairing is necessary during that time except the occasional replacing of a fire-brick near the tuyères. The campaigns might even last longer if the "tutty" forming in the upper part of the shaft did not render interruption necessary.

In charging, the fuel is placed in the middle and along the breast, while the charge is thrown in in the form of a semicircle over the tuyères. By means of a valve in the flue, the exit of the gases is so regulated that the outer air exerts only a small pressure on the furnace gases. In consequence of this the fumes draw off slowly; their quantity is reduced to a minimum; the gases never ignite on top of the furnace, and even during the charging little lead is lost by the draft.

The effect of this arrangement is important. Before its introduction the gases ignited often on top, and the settlings of the condensing-chambers burned like tinder. They were then light and voluminous, and were carried along by the draft; now they are gray, metallic, and heavy, and contain 50 to 60 per cent., whereas they formerly contained only 35 to 40 per cent. Previous to 1865 the entire loss in the old furnaces, with open top and two meters high, was 7 to 8 per cent., half of which was lost in fumes; now it is only 4 per cent., of which over 2 per cent. are fumes. From 6 to 7 per cent. of the ore is saved as condensed fumes in the new furnace.

The ores of Pallières contain after roasting, on an average—

Oxide, sulphate and sulphide of lead	500
Oxide of iron with some sulphide	300
Quartz	200
	1,000

the contents of lead being 40 per cent., 110 kilograms of which hold 110 grams of silver.

The following fluxes are used:

	Per cent.
Limestone	20 to 25
Rich iron ore	3 to 4
Cast iron	2 to 3

and it is intended to make a slag of the following composition:

	Per cent.
Silica	30
Protoxide of iron	40
Oxide of calcium	20
Alumina and oxide of magnesium	5 to 6
Oxide of lead	2 to 3

The contents of sulphur in the slag must not exceed 1 per cent. and the contents of silver are not to be more than one gram in 100 kilograms.

If the ore has been imperfectly roasted some matte is formed, which passes into the slag. In experiments to smelt raw sulpho-carbonates with the common ore (galena with sulphuret of iron) which had been slightly roasted, with the addition of 7 per cent. cast iron and 20 per cent. of iron ore, the resulting slags were mixed with matte and contained much silver. The more carefully the roasting is carried out, the more perfect is the extraction of silver. According to this it would be advisable to leave the 2 to 3 per cent. cast iron altogether out of the charge and to take in its stead the corresponding amount of iron ore; and also to contract the furnace in the smelting-zone. The smelting would then take place easier and a little oxide of iron would be reduced, as in the Rachette furnace in the Hartz.

Eight to ten tons of roasted ore are smelted at Pise in twenty-four hours, with 25 per cent. of coke, and the lead is tapped two to three times daily into an iron kettle, which is preferable to a sump cut out of stübbe. The added cast iron often acts only as fuel. At Pise the consumption of coke fell from 25 to 22 per cent., when 7 per cent. of cast iron were added instead of 3. At Pontgibaud, where the ores contain 50 per cent., the effect of iron is still more apparent. With 10 per cent. of cast iron 8 to 9 per cent. of coke were used, and with 12 per cent., less than 7 per cent. In both cases not a trace of matte was formed, the iron being mostly oxidized.

In the smelting process at Ems, Prussia, a Rachette furnace, with twelve tuyères, is used, and in twenty-four hours 15 tons of charge are smelted, consisting of 100 roasted ore, with 50 per cent. lead, 24 puddling slag, 24 spherosiderite, 16 limestone. Ten per cent. of cokes are used, while formerly, in the old furnaces, 20 to 30 per cent. were consumed. The saving is effected, however, less by the shape of the whole furnace than by its narrowness in the smelting-zone.

The process at Freiberg.—About two years ago a modification of the Castilian furnace was introduced at Freiberg. It differs from the former in the horizontal section, which is eight-sided instead of round; seven tuyères have been placed around the periphery, and it is closed as a "sump-furnace." As at Pise, near Alais in France, a flue for the removal of the gases into the chambers is built in one side near the top, and in a manner similar to the arrangement in iron blast-furnaces; an iron cylinder is inserted into the top, behind which the gases enter the flue. Through a funnel on top of the cylinder the furnace is charged by cars, the bottom of which can be let down. The furnace is 4 to 5 meters high, in the level of the tuyères 1.55 meters wide, and on top 2.12 meters. The tuyères are cooled by water, and the breast rests on an iron box filled with water. This, it is true, is a great improvement on the old furnaces, but iron walls should be used in the smelting region, as at Pise; the furnace ought to be still more contracted in this portion, and the fore-hearth ought to be discarded. The upper part of the furnace is independent of the lower, and rests on iron bars which are suspended from above, so that the lower part can be separately repaired. The charge is little changed. As formerly, 45 to 50 per cent. of roasted first matte are added to the ore, but instead of 150 per cent. of lead-slag, only 85 per cent., and 2½ per cent. of limestone are added. The economy is not perfectly satisfactory, as 24 parts of coke are still used in treating 100 parts of ore. The furnace seems to be too wide in the level of the tuyères, and the charge is too voluminous. The amount of the slag, and perhaps that of the matte, should be lessened, and a part of the latter replaced with lime. Nevertheless, this is a considerable improvement, 31 parts of coke having been used formerly for 100 parts

of ore. Poorer mattes are now produced, and slags which can be thrown away, containing in 100 kilograms only 1.5 kilograms of lead, 0.1 kilogram of copper, and 1 gram of silver. In twenty-four hours 15 tons are smelted, and lately this has been increased to 20 tons.

Furnaces of the same kind, only differing from the Freiberg furnace by their round shape and the number (5) of their tuyères, have been erected at Braubach and Clausthal. In the latter slags are now made which contain only ½ per cent of lead.

As I have mentioned above, this furnace has also been introduced at Eureka, Nevada, and it is reported that excellent results have been obtained; but I have not yet received exact figures.

IV. REFINING OF THE LEAD AND EXTRACTION OF THE SILVER.

Neither of these processes is as yet practiced in the West, and it is probably, under present circumstances, best that they should be executed at commercial centers. The principal reason for this is the insecurity and high freightage of fine bullion shipments, both of which are avoided in shipping base bullion.

Lead is refined, either for the purpose of using subsequently the Pattinson process for the silver extraction, or to obtain a pure article for the trade. If the lead is tolerably pure, it is sufficient to remelt it in a reverberatory or an iron kettle at a low temperature, draw off the dross, and "pole" the fluid mass. But if the lead is very impure it must be repeatedly calcined at a red heat in a reverberatory, under access of air; and even this does not suffice when antimony is present. In that case a blast is used in some works; in others, superheated steam. The latter shortens the process, and has given generally good results.

When, besides antimony, much copper, iron, or nickel, or other not easily fusible substance is present in the lead, the calcination is, in some localities, preceded by eliquation, or the heating of the mass to the melting-point of the lead, which is then drained off, leaving a sponge of the less fusible metals. These must be subjected to further treatment, both on account of their own value and to recover the amount of lead which still inheres in them; and since this reworking involves considerable loss of metal, eliquation is willingly avoided by metallurgists. Where it is employed the object is to reduce the time, labor, and expense required for the calcination of a highly refractory material; and when this end is not secured by eliquation, that process is not to be recommended.

Direct cupellation of the whole product of lead has nearly everywhere ceased to be employed for the desilverization of lead, partly because there is no market for the large amount of litharge thus produced, and its reduction to metal adds to the cost of the process, and partly because in most crude lead the contents of silver are too small to permit an economical extraction in this way. The Pattinson process also is gradually giving way to the desilverization by means of zinc, originally known as Parke's method, but considerably improved by later experimenters. In this country a similar process is carried out at Newark, New Jersey, with this principal difference from the original, that the zinc containing the silver is not skimmed from the surface of the molten lead, but retained in a reverberatory in the dross, after the lead has been removed at a low temperature by a process of eliquation. It is based on the fact that lead melts out of an alloy of zinc, silver, and lead, before the other two metals become liquid, and that the silver has a greater affinity or zinc than for lead. The objections to eliquation, mentioned above,

do not obtain in the present instance, since the lead is pure, and the argentiferous residuum requires no other treatment than a simple distillation and cupellation. The manipulations are, therefore, not rendered inconveniently numerous or complicated.

The zinc process, as practiced in the small works at Braubach, on the Rhine, is described by Professor Gruner as follows:

Lead is treated here which contains gold, silver, and copper. Twelve tons of lead are melted and 2 per cent. of zinc is added in three periods. A thorough mixture is secured, after each addition of zinc, by stirring the whole mass for half an hour; then the charge is permitted to cool, and after three hours the zinc-scum is drawn off. The whole operation, therefore, lasts twelve hours. The zinc absorbs from the lead first the gold, then the copper, and finally the silver.* The zinc-scum, which is first partially freed from lead by heating it up to the melting point of the latter, is then mixed in a cast-iron kettle with chloride of lead, and raised to a dark-red heat. Chloride of zinc and lead rich in silver are obtained. The latter is cupelled. The great mass of the lead from which all the silver has been extracted is likewise treated with chloride of lead to free it from zinc; and the slag containing the chloride of zinc is smelted in a reverberatory or a low blast-furnace, for the purpose of obtaining the particles of lead mechanically mixed with the slag. It would probably be better to treat the slag with water, which dissolves the chloride of zinc. The lead contains after the treatment less than 10 grams of silver per ton.

At Lautenthal,† in the Harz Mountains, a modification of Cordurié's process has been introduced. Here 25,000 pounds‡ of lead are melted in a Pattinson kettle; and after the dross is removed 1.4 per cent. of zinc is introduced at three periods, the mass being each time energetically stirred and then left for some time quiet, in order to give the zinc, containing the silver, a chance to separate. The whole proceeding takes eighteen hours. The stirring is done by a vertical shaft with arms, to the lower end of which a box with holes in the top is affixed to receive the zinc. This is added in small solid pieces, and as soon as introduced into the molten mass melts also and ascends in fine streams through the lead to the top, taking up the silver on its way. As products of this treatment, are obtained:

a. Desilverized lead, containing some zinc and antimony. To remove these, steam is introduced into the lead from the bottom of the kettle. This oxidizes the zinc and also some lead, while hydrogen is evolved, and the oxides rise to the surface. During this process the kettle is covered with an iron hood, from which the steam and gas are conducted by a pipe into a condensing chamber. The presence of zinc in the molten lead is tested by taking a sample from the bath with a ladle. If, on emptying the ladle, flaps or clouts of metal are observed to adhere to it, the zinc is not yet completely removed from the lead. But

* This statement of Professor Gruner is contradicted by an article in the Berg und Hüttenmännische Zeitung, (1869, p. 271,) from which I extract the following passage: "Regarding the affinity of different metals for zinc, it has been found that when a small quantity of zinc is added to lead containing copper, gold, and silver, the copper is first absorbed by the zinc; if the resultant alloy of zinc and copper is removed, (for further treatment by matte-smelting,) and another small addition of zinc is made, the gold is next absorbed, and only by adding a larger quantity of zinc is the silver thus extracted from the lead. Perhaps it would be feasible by means of such a graduated successive treatment of a lead-alloy containing copper, gold, and silver, to effect the separation of these three metals." The practicability of an accurate separation by such means I am inclined to disbelieve.

† Berg and Hüttenmännische Zeitung, 1869, p. 271.

‡ Prussian pounds, equal to 25,775 English avoirdupois.

when these are no longer formed, and a white crystalline spot (specular antimony) shows itself in the middle of the cooled sample, the zinc is gone and the antimony has then to be eliminated. The hood is removed after first conducting steam directly under it in order to drive out the hydrogen and to prevent explosions, after which steam is conducted into the metal bath under access of air, until a sample shows no more antimony, the surface appearing uniformly lead-gray. The oxides are then removed from the surface of the metal in the kettle, and the lead, of excellent quality, is ladled into molds.

The oxides, containing lead and zinc, are concentrated mechanically in the wet way, and two products are the result: Oxide of zinc of a yellowish-green color, containing 30 to 33 per cent. of lead, and oxide of lead, poor in zinc, which is smelted with other refuse.

b. Zinc rich in silver, with some lead, (zinc-scum.) This is melted in a kettle, and, after putting on the hood, steam is introduced, when the lead separates, leaving a scum rich in oxides of silver and zinc. This is added afterward, in cupelling the lead after the first oxides have been drawn off. The scum which appears during this subsequent cupellation on the lead contains still some silver and is therefore returned into the smelting processes.

This method gives far better results than the Pattinson process formerly in use.

SEPARATION WITH ZINC AND CENTRIFUGAL FORCE.

Mr. Eyster, of Colorado, has lately published in the Engineering and Mining Journal his process for the desilverization of lead by zinc, which is evidently intended to secure the more intimate distribution of the zinc through the lead and the final separation of the lead and the alloy of zinc and silver, by means of centrifugal force. This latter idea is entirely new, but the experiments thus far made are not conclusive yet as to the economical advantages of the process. The description of the process by the patentee follows here:

The cylinder which I first experimented with was only 9 inches in diameter; the one I now have is 15 inches in diameter and 3 inches in length on the inside, that is, from head to head. The principles which underlie my process are:

First. That metals when in the metallic state do not enter into chemical combination when mixed or alloyed together.

Secondly. That metals when alloyed and reduced to a fluid condition and kept at rest in that condition for a considerable length of time, say an hour or more, in a deep vessel, will become partially or approximately separated, according to their respective specific gravities. A familiar illustration of this is to be seen in a brass foundery—brass being composed of copper and tin, if kept at rest in a molten state for an hour will so completely separate as to destroy the quality of brass.

Another well-known instance of the same transposition is this: If silver and gold be mixed, reduced to the molten condition, and kept in that state for an hour in a narrow and deep crucible, and then allowed to cool without agitation, most of the gold will be found at the bottom of the crucible and most of the silver at the top.*

This result is accountable for on the principle that when these metals are reduced to the fluid condition by heat, their atoms are free to and do arrange themselves according to their respective gravities. When these metals are mixed and fused, each atom of each metal retains in its atomic state all of its properties and chemical characteristics. It would require too much space for me to go into detail on this subject, and I content myself with simply stating the general principles.

If when metals are thus mixed and in fusion you employ mechanical force to assist their natural tendency to separate, you will accomplish that result in proportion to the force applied. The force which I apply is centrifugal force, generated by the rapid rotation of a hollow iron cylinder, in which the molten metal is placed for that purpose.

---

* I do not vouch for this statement. I have never observed such a separation myself, and I am inclined to doubt its occurrence. Mr. Eyster's theory appears to me too weeping. His experiments with zinc, silver and lead, on the other hand, are as reasonable as they are ingenius and interesting.—R. W. R.

The cylinder I now have for experiment is made of cast iron, three-quarters of an inch thick, 15 inches in diameter inside, and 3 inches thick, that is, from head to head, so that the cake or ingot of metal after treatment will be of these dimensions. The cylinder is cast with one of its heads attached. In the other end is a flange 2 inches wide, on which the other head of the cylinder is fitted, so that it may be put on and taken off at pleasure by means of bolts and keys or screws. This flange, and the head that fits on it, must be made so that the joint will be close, and so constructed that it may be luted and made perfectly close or tight when it is put together for use. From the center of each of the cylinder-heads protrudes an axle, cast with it, and made strong enough for the purpose, on which the cylinder revolves. On the top or circumference of the cylinder is a hole about one inch in diameter, through which the cylinder is charged with the molten metal, and which is opened and closed with a screw or other appliance so as to be perfectly close. On one of the axles is fitted a spur-wheel, by means of which the cylinder is made to revolve. I have a bed-plate cast with journal-boxes, on which this cylinder is to be placed when ready to be operated. This bed-plate is placed on the top of a small furnace, of sufficient capacity to generate heat enough to keep the cylinder as hot as the metal to be treated.

I place the cylinder in its bearings over the furnace, make up a small fire, and revolve the cylinder slowly over it, so as to heat it up to the temperature of the metal to be treated. I then open the vent on the top, pour in the metal to be treated, close up the vent, and commence to revolve the cylinder, at the rate of about 250 to 300 revolutions per minute, keeping in the furnace just heat enough to keep the cylinder hot, and the metal within it in fusion. After I have revolved the cylinder thus for three hours, I withdraw the heat, keeping up the rotation until the cylinder is cold, and the metal within it solidified. (This will be accelerated by a blast of cold air blown into the furnace.) I then lift the cylinder from its bearings, take off the movable head, and turn out the cake of metal, when I find the lighter metals in the center, and the heavier ones on the outside, so that they may be cut apart in a lathe, or by any appropriate instrument.

I do not claim that this process will make an exact separation, unless, perhaps, when there were but two metals, when one might be cut pure from the inside, and one pure from the outside, leaving an intermediate ring or band to be treated again with others of like value.

Having thus described my method, I will now give the result of two experiments which I made recently, one in the small cylinder with very rich lead, and one in the large cylinder with very poor lead.

The first experiment, as I said, was with very rich lead; according to assay it contained $1,100 to the ton. It was made in the small cylinder. I melted sixty pounds of this lead, containing about $33 of silver. I added to it nine pounds of zinc, and after heating my cylinder to the temperature of the molten metal, or a little more, I opened the vent on the top and poured in the metal. Closing the vent, I revolved the cylinder slowly for a few moments. This is done to mix the silver, lead, and zinc. I then stopped the rotation, and allowed the cylinder to stand for ten minutes. This I did to enable the zinc to come to the top mixed with the silver, which it will do by reason of its specific gravity. I then turned the cylinder rapidly half round, so as to throw the zinc to the bottom, whence it would again ascend to the top, by leaving the cylinder at rest for ten or fifteen minutes. This may be repeated three or four times, as by such manipulation, and a very slow motion of the cylinder, I obtain a most intimate mixture of the zinc with the mass, and thus bring it in contact with all of the silver in the mass, which the zinc, by its superior affinity, takes up, reducing the gravity of the silver to the mean between that metal and zinc, making it about 8½, and leaving the lead at its original gravity. After I had thus treated it, I commenced to revolve the cylinder at the rate of 300 revolutions to the minute, and continued its motion at that rate for two hours and a half, keeping up heat enough in the furnace to keep the metal in fusion. At the end of two and a half hours, I withdrew the fire and cooled the furnace with water, keeping up the rotation of the cylinder at the same speed until it was cold and the metal within it solidified. I then lifted it off from its place, took off the head, and turned out the ingot, which was nine inches in diameter and three inches thick, with a hollow core in the center.

By means of concentric circles I divided this mass into eight rings, which I numbered, commencing with the outer one. A small section across all these rings, in the direction of the radius of the circles, was taken for assay to the mint, and gave the following results: No. 1 contained 1.7 parts of silver; No. 2 contained 3 parts of silver; No. 3 contained 11.5 parts of silver: No. 4 contained 268 parts of silver; No. 5 contained 519 parts of silver: No. 6 contained 545 parts of silver; No. 7 contained 553 parts of silver; No. 8 contained 624 parts of silver. These are the mint figures, and show, as you see, a concentration of 624 to 1.7. It illustrates also the principle in the gradual increase of silver from the outside to the inside. A few pounds more of zinc added to this experiment, and a longer period of rotation, would, I have nc doubt, produce a much more decided result.

The second experiment was with the 15-inch cylinder, and with 180 pounds of lead, containing $20 of silver per ton. This experiment was prepared exactly as the former one. I heated the cylinder up to the proper point, that is, the temperature of the molten metal. I then poured in the melted metal, adding to it five pounds of zinc, and mixed as before stated by slow motion and stopping the cylinder. I then commenced to revolve the cylinder at a rate of from 250 to 300 revolutions per minute. I kept this up for three hours, keeping at the same time heat enough to keep the metals melted. At the end of three hours I withdrew the heat, and kept up the rotation of the cylinder at the same speed until it was cold and the metal solidified, when I stopped it, took off the cylinder, took off the head and turned out the ingot of the same shape as that from the first experiment, but of larger size. In this instance the metal was divided in the same manner as before, but the number of rings was increased from eight to fourteen.

Fifteen grains from No. 1 gave so small a speck or point of silver that it was with difficulty it could be seen in the cup with the naked eye. Professor Schirmer said it was not more than would be in the same quantity of litharge. He says practically it amounts to nothing. The others gave the same results up to No. 12, which had an appreciable quantity; No. 13 a little more; No. 14 quite a respectable globule. We did not weigh them, as I was desirous to keep them in the cupels for exhibition to friends, as out of the cups none of them could have been weighed in the most delicate scales, except Nos. 13 and 14.

All of the experiments which I have made produced similar results, and I am now fully satisfied that every succeeding effort which I make will produce the same result. Indeed, when I have an engine or other force to drive my machinery, so that I can continue the rotation of the cylinder for six or seven hours, the result will be a perfect one. I now desire to procure a wrought-iron cylinder of the capacity of from 1,200 to to 2,000 pounds. With this apparatus, and this mode of treatment, I feel confident that I can concentrate the silver that is in one ton of lead into 100 pounds, at an expense of less than $5 per ton, thus saving the expense of cupelling 1,900 pounds of lead.

The zinc to be used in the process is to be distilled from the solid metal, converted into metallic zinc and used over again in a similar succession of processes, so that there is no loss. We find no trace of zinc in the samples outside of No. 12.

When I speak of the cost of concentrating a ton of lead, I speak with reference to the cost of working an establishment of the capacity of five tons per day. All the hoisting and lifting of cylinders would be done by means of cranes and pulleys, and the cutting of the concentrated metal by means of an upright lathe with an adjustable cutter. Four men and one ton of coal would treat five tons per day with great ease.

CORDURIÉ'S PROCESS.

Professor Fred. Prime, jr., of Lafayette College, Easton, Pennsylvania, has translated a memoir by Messrs. Wedding & Braeuning, originally published in vol. xvii of *Zeitschrift für das Berg, Hütten und Salinen-Wesen in dem preussischen Staate*, on Mr. Cordurié's modification of the desilverization of lead by zinc, which is especially valuable for this country, as our western argentiferous galenas generally contain many impurities, the removal of which from the lead, subsequently to the desilverization, is one of the principal objects of this process. With the permission of the translator I introduce his work here in full. It originally appeared in the columns of the Technologist, an illustrated industrial magazine, published in New York.

The process may be divided into: First, desilverization of the lead; second, refining the desilverized lead; third, treatment of the zinc scum.

DESILVERIZATION OF THE LEAD, AND REFINING THE DESILVERIZED LEAD.

At the works of Baron Rothschild, in Havre, Spanish lead is smelted, containing 0.04—0.06 per cent. silver, and but very slight traces of antimony. The desilverization and refining are carried on in different kettles. According to Cordurié's plan, the desilverizing kettle should be plac ed at a higher level than the other, in order that the desilverized lead may be tapped off into the refining kettle; but at Havre, in consequence of local conditions, all these kettles are placed at a level, so that

the desilverized lead must be ladled out. As this is much less advantageous than the plan proposed by Cordurié, the latter is shown in Fig. 4, of the plate. In this, *a* designates the desilverizing kettle. This is perforated at the bottom, where the discharge pipe, *b*, is affixed, from which the lead is conducted by a forked gutter, *c*, into the refining kettle, *d*. The closure is made by a stopper, *w*, which is inserted into the pipe *b*.

The disposition chosen at Havre is shown in ground-plan in Fig. 1, and in vertical section in Fig. 2, and the corresponding parts are lettered as in Fig. 4. The kettles are cylindrical, with almost hemispherical bottoms. The thickness of the iron at the bottom is 3¼ inches—being twice that of the sides. The desilverizing kettle holds 22,000 pounds of lead; the refining kettles are correspondingly smaller, there being two of these to each desilverizing kettle; lower are small kettles for liquating the zinc scum, one of which is placed alongside of each desilverizing kettle. The fires under the different kettles are independent of each other, the flames being conducted spirally around the kettles; *r* is the common flue for the kettles *a* and *l*; *p* that for the kettle *d*. Both these and the flues of the boiler discharge into one chimney. At Havre, the boiler is a simple cylinder 13.1 feet long and 20 inches in diameter. These dimensions are more than sufficient to serve simultaneously two systems of two refining kettles each.

The steam supply pipe, *n*, is conducted along the flue *p*, by which a superheating of the steam is effected. There is an arrangement, *q*, (see Fig. 1,) at the lowest point, by which the condensed water can be blown out of the pipe before the commencement of the operation.

The refining-kettles, *d*, are closed by a movable hood of sheet iron, fitting into a groove on the edge. The hoods are connected by sheet-iron pipes, *f*, with condensation chambers, *g*, of which there is one for each system. At Havre, the condensation chambers are of sheet iron, and evidently of too small cubical contents.

Manner of working.—The work is commenced by mixing the zinc with the lead, melted in one of the desilverizing kettles, by means of a mechanical stirrer, represented on a larger scale in Fig. 3. The vertical shaft, *a*, is set in rotary motion from the crank, *c*, by the conical wheels, *b b*. To the shaft, *a*, is attached the box, *d*, perforated like a sieve, in which the zinc is placed, and this, filled with pieces of zinc, is closed by the cover, *k*, which is fastened in place by the wedges, *l l*. Above the box, and attached to the shaft, are two skew-wings. The whole is supported on the frame, *e e*, which can be moved on rails over the desilverizing kettle. When beginning the work, the shaft, *a*, is sunk so deep into the metal, that the box containing the zinc is suspended near the bottom of the kettle. The shaft is passed through the collars, *f* and *g*, and the wedge, *h*, inserted below the collar, *f*, prevents its being lifted out of position by the motion of the apparatus.

The shaft is set in rotary motion so soon as the box containing the zinc has been sunk in the kettle, thus producing a distribution of the rising drops of zinc by means of the skew-wings. After the zinc has been intermixed the connection of the conical wheels is loosened, the wedge, *h*, removed, and the shaft lifted by a system of pulleys. For this purpose the collar, *g*, is movable on the points, *i*, so that the box can be lifted above the level of the frame, *e*, and held in this position by placing under it a double claw resting on the supports, *m m*, and the whole apparatus may be rolled away from the kettle.

This mechanical stirrer, not effecting the complete distribution of the zinc in the lead, it is found necessary, after each addition of zinc, to stir

for some time with skimming-ladles—an operation which, in the opinion of the officers, might be dispensed with if the wings were made larger and two sets placed on the shaft, one over the other. It is intended to make such a change in the apparatus at Havre. Were the stirring apparatus, as it easily might be, moved by steam, much manual labor would be avoided.

The amount of zinc used at the Rothschild Works is 1.1 per cent; the length of time necessary for melting and ladeling out, twenty to twenty-four hours; the amount of silver in the desilverized lead is 0.0005 per cent., or 79 grains in a ton. If the difference in the percentage of silver in the lead be considered, these results closely coincide with those obtained at the Hartz Works, where, in twenty-four hours, a kettle of 25,775 pounds of lead, with 0.0104 to 0.0125 per cent. of silver is desilverized by 1.4 per cent. of zinc, to 0.0005 per cent. silver. The zinc scum, after being liquated in the small kettles at a tolerable high temperature, is quite dry, and contains 2½ to 3 per cent. silver. It is subsequently treated, while the liquated lead is returned to that in the desilverizing kettle.

In order to free the desilverizing lead from zinc, it is brought into both of the refining kettles belonging to each desilverizing kettle, which hold about 11,000 pounds each. The kettles are heated to light cherry-red heat; the hoods are then set on, the steam-conducting pipe is passed to the bottom of the kettle, and steam injected into the metal bath, at a pressure of four atmospheres. A violent oxidation of the zinc takes place under a disengagement of hydrogen, the temperature in the kettles is much increased by the chemical process, and in about three hours the whole of the zinc is oxidized, and the antimony also removed; of this, as already mentioned, there exists but a small quantity in the lead. The oxides are a mixture of oxide of lead and oxide of zinc, in which many particles of metallic lead are also mingled. Though no figures with regard to the amount of this last can be given, from their appearance, the quantity, as in the Hartz, is at least 2 to 3 per cent. of the original amount of lead. The mercantile lead produced is apparently of a very good quality; it is ladled out into pans, movable on two wheels. The condensation chambers are evidently too small to collect all the fine oxides which have been carried off. The production of refined lead is stated as 82 per cent., while the quantity of English coal used is given as 8 to 10 per cent.

Two systems are always worked together—desilverizing and refining two charges of 22,000 pounds in twenty-four hours. Both systems are served by six workmen, who alternate in twelve-hour shifts, so that but three workmen are employed at one time. Two of these serve the desilverizing kettle, while the third attends to the boiler and the kettle containing the desilverized lead. The ladling out of the mercantile lead is done by special workmen, who are paid 30 cents* per 2,200 pounds, while the other workmen earn from 80 to 100 cents daily. The total cost of this portion of the process, with the exception of losses, (estimated at 1 per cent.,) may be rated as follows:

	On 100 weight of lead.
Wages—For 44,000 pounds are required 10 shifts at 90 cents	2.04 cts.
Coal—For 2,200 pounds of lead are used 220 pounds of coal, costing 50 cents	2.20 cts.
Zinc—The amount of zinc used for 2,200 pounds of lead is 22 pounds, costing 112 cents	5.08 cts.
	9.32 cts.

* All moneys are given in coin value of the United States.

* The exact and detailed results are tabulated at the end of the memoir.

When this process was introduced into the Lautenthal Silver Works, the existing Pattinson battery was used unaltered, the kettles being simply provided with hoods, which are connected with larger condensation chambers than at Havre. The desilverization and refining are carried on in the same kettle, which holds 27,500 pounds. Steam, having a pressure of but one atmosphere, is conducted into the metallic bath heated to a cherry-red heat, and the whole is completely freed from zinc in about three hours. An attempt to remove contemporaneously, as at Havre, the antimony, which is here present in considerable quantities, was unsuccessful; to do this the zincous oxides are first removed, the hood is then set on loosely, doors in it are opened, so that the air can have access, and steam is conducted in for about an hour longer. By this means black abstrich, similar to that formed by poling, results, with the advantage of holding the zincous oxides apart from the antimonial products. The zinc scum is liquated in common desilverizing kettles, at a less elevated temperature. A zinc scum is obtained, containing about $1\frac{1}{2}$ to $1\frac{3}{4}$ per cent. silver. It will hereafter be shown that this, which contains more lead, is more readily decomposed by steam than the dry, very argentiferous, and zincous zinc scum obtained at Havre. The lead, liquated at a lower temperature, and hence containing less silver, is completely desilverized in the ordinary manner by skimming; as the liquated lead contains a surplus of zinc, none (or if any a very small quantity) need be added. The Hartz liquating operation appears more advantageous than that used at Havre, since the labor of ladling the liquated lead into the desilverizing kettle is altogether avoided.

The direct yield of refined lead is about 80 to 84 per cent.; about $1\frac{1}{4}$ per cent. of the lead goes into the zincous oxides, which consist of about 55 per cent. of lead, and 0.8 per cent. goes into the antimonial abstrich. The rest of the metal passes into the zinc scum, the lead reduced from the first scum, and the lead refuse formed after the removal of the antimony. The amount of coal used in desilverizing and refining is about ten per cent. The total cost* of this process (except loss, pay of director, and wear of the kettle,) is about 12.5 cents per hundred weight, (110 pounds:)

Wages	1.9 cts.
Zinc	7.5 cts.
Coal	3.0 cts.
	12.4 cts.

These expenses would probably be somewhat reduced with more practice and greater production, by a saving in wages and coal. The loss, so far as examined, amounts scarcely to 1 per cent. of the lead originally placed in the kettle; while, according to the fire assay, there is no loss in the silver present, but, on the contrary, a slight increase, as is generally the case in well-managed smelting works. The following analysis shows the excellent quality of the lead deprived of zinc by means of steam:

Lead	99.9913
Copper	.0022
Antimony	.0052
Zinc	
Iron	.0007
Silver	.0006
	100.0000

* The exact and detailed results are tabulated at the end of the memoir.

If the operations at Havre and in the Hartz are compared, the first striking difference is that, at the former place, the lead is deprived of zinc, in special smaller refining kettles, under high pressure. The dezincation is carried on in special kettles, as it is feared that light rich argentiferous crusts may remain clinging to the sides of the desilverizing kettle, which will not be removed by skimming, and which may impair the desilverization of the lead. This result has never been observed in the Hartz, where the desilverization is carried just as far as at Havre, and completed in the same time. The reason given for using smaller refining kettles at Havre is that the process is thus hastened, while a better quality of lead is thought to be obtained by the higher pressure of the steam; but, as already stated, the dezincation is effected at the Hartz in larger kettles, under a low steam pressure, in the same time as at Havre.

TREATMENT OF THE ZINC SCUM.

1. *Treatment of the poor zinc scum.*

The attempt to remove the antimony contemporaneously did not prove successful; but this could not be attained when tried with steam under a pressure of four to five atmospheres. That a special removal of the antimony is not necessary at Havre is probably owing neither to the arrangement of the kettles nor to the use of high-pressure steam, but to the small amount of antimony in the lead, to remove which the refining process is perhaps sufficient; and if the different capacities of the kettles are considered, it is found that the dezincation and removal of the antimony occupy the same time in the Hartz as the dezincation alone does at Havre. It would therefore appear that there is no advantage in desilverizing and dezincizing in special kettles with high-pressure steam. Even a superheating of the steam appears to be scarcely necessary; at least in the Hartz its use made no apparent difference. It is only requisite that the steam should be dry, as otherwise the latent heat needed to convert the water anew into steam causes a greater consumption of fuel. From a comparison of the costs it is evident that they are about alike at Havre and the Hartz, if no account be made of the different quantities of zinc which are dependent on the amount of silver in the lead. If the Cordurió and simple poling process are compared, the direct cost of the desilverization and refining will be found about the same. A slight advantage would in time be gained by the steam method in shortening the process and consequently saving labor and fuel. The small quantity of plumbiferous oxides and the consequently larger quantity of refined lead produced by the steam process, give it an important advantage, while the zincous oxides are available as paint. Moreover, the steam method admits readily a complete closure of the kettles, thus preventing the loss of lead and rendering the work less injurious to health. In dezincation by poling such a closure cannot easily be employed, not only because the pole must frequently be replaced, but also that the oxidation of the zinc being almost entirely due to the oxygen of the air, a complete exclusion of this is not desirable.

As used at Lautenthal the steam method demands no expensive plant. Every Pattinson battery may, at a slight outlay, be altered to serve it. Condensation chambers of but small extent are needed, since the oxides carried off fall easily with the steam. It therefore seems evident that the steam process has the advantage over all other yet known methods for refining the zincous desilverized lead. In a new establishment it would be advisable to provide the kettles with a tapping arrangement,

so that the lead might flow directly into the pans, and thus do away with the laborious and tedious ladling out. The plug recommended by Cordurié is less suitable for the purpose than the slide used in some of the Rhenish lead works. Of this the tapping-pipe ends in a triangular flange, on which there is a movable lever, which is pressed against by an iron plate held in position by screws; both the flange and the inner side of the lever, by which the tap-opening is closed, must be planed very smooth, so as to produce a complete closure. For safety the tap-opening is also closed by a brasque plug. If stopped by solidified lead the tap-opening is easily cleared by running a hot-iron bar into it. The translator saw this slide arrangement used at the works of the Stolberg company, near Aix-la-Chapelle, where it worked admirably.

The oxides produced in the Cordurié method of refining the lead are so rich in zinc, and occur in such a fine state of division, that the great mass of oxide of zinc can be easily separated from the oxide of lead by a simple elutriation.

The following manipulation is used at Havre for this purpose: The oxides are first washed with a little water on an inclined plane, six feet long, divided into two sections by a traverse. The particles of lead remain in the upper section, a portion of the plumbiferous oxides is collected in the second section; but the great mass of the oxides pass through a sieve in front of the flame, into a large reservoir. The lead particles are returned to be refined, the plumbiferous oxides are reduced in a reverberatory furnace, while the great mass of the oxides, composed of almost equal parts of oxide of zinc and oxide of lead, are subjected to a further separation by decantation. For this purpose three casks, about four feet high and four feet in diameter, are placed one above another. These are provided at various heights, with tap-openings. The oxides are placed in the upper cask and stirred up with water. They are then allowed to settle and the rich zincous oxides, which lie on top, are tapped into the second cask. The same operation is here repeated, the highest portion goes into the lower cask, the heaviest is returned to the upper one. In this manner, plumbiferous oxides, with about 60 per cent. lead, and zincous oxides, which retain 30 per cent. lead, are obtained. The first, like the rich oxides to be hereafter mentioned, are treated with hydrochloric acid in order to remove the zinc and fit them for reduction. The latter are well dried, and it is intended to sell them as paint, for which they are said to be excellent, their quality being improved by the lead they contain; for, though their tint is not pure white, they require less oil than zinc-white. These oxides are particularly good for painting wood, and answer better than zinc-white for a first coat or where a pure white color is not necessary. It is therefore hoped that the zinc oxides, equal to about one per cent. of the original amount of lead, may be sold at a relatively fair price.

In table 2 we give a plan of the processes and intermediate products for the purpose of affording an easy tabular view.

In the Hartz.—When washed at the Lauthental Silver Works, on an inclined plane, the greater part of the poor oxides remained in the residue, which contained upward of 85 per cent. lead. Hence it appears that this substance essentially consists of metallic lead and oxide of lead, and can, therefore, be reduced without difficulty. The remainder of the oxides are conducted into the collecting vessels as a fine silt. They contain only thirty per cent. lead, and are of a yellowish tint. If used as a metallic color, the presence of oxide of lead would appear advantageous. The results obtained at Havre can, therefore, be had without decantation by the use of a better method of concentration, as

by this means the separation of almost equal portions of oxide of lead and oxide of zinc, and the consequent treatment by hydrochloric acid is entirely avoided. The price of hydrochloric acid being much greater in the Hartz than at Havre, it will scarcely be employed there for the treatment of the plumbiferous residues, and it is hoped this may be better done by a simple reduction. No estimate can be given as to the amount of acid used in treating the poor oxides at Havre, since sufficient quantities have not yet been worked for the formation of a correct opinion.

2. *Treatment of the rich argentiferous zinc scum—steam process at Havre and in the Hartz.*

Cordurié not only originated the use of steam for dezincation of lead, but first called attention to the use of steam in the further treatment of the rich zinc scum. When the zinc scum from the desilverization is treated with steam, the zinc-silver-lead alloy it contains is decomposed, and a mixture formed of oxide of zinc and oxide of lead with rich lead. The oxides are still argentiferous, the silver they contain being due to grains of rich lead, mechanically intermixed, and also to a tolerably infusible lead-silver-copper alloy. The latter frequently attaches itself in considerable quantities to the hood covering the kettles, so that the amount of silver increases with that of copper, up to 9 per cent. The formation of this alloy is caused by the lead thrown against the sides of the hood (and therefore into the oxides) which liquates out till an alloy remains which no longer melts at the light-red heat of lead. To avoid forming this alloy, as far as possible, the steam must not be allowed to stream with too great force through the metal, nor must the zinc scum be taken off too dry, since lead is then wanting and the alloy rich in silver and copper is more easily produced. Moreover, the zinc scum, deficient in lead, requires an excessively high temperature to bring the mass to a semi-fluid condition fit to be treated with steam.

At Havre, where the zinc scum is taken off very dry, the oxides contain more silver than the rich lead separated; while in the Hartz the reverse is true, since the zinc scum contains more lead. In the latter case, the rich lead contains about 1½ to 1¾ per cent.; the rich oxide above 1½ to 1 per cent. silver. As a consequence of the high temperature, the kettles used for treating the zinc scum at Havre are rapidly destroyed, while after four months' use a change was not found necessary in the Hartz. It may also be mentioned that there a steam pressure of but thirteen to fifteen pounds is used in this stage of the operation; and at Havre, on the contrary, four to five atmospheres, yet the period of the operation is no shorter than in the Hartz. At both places, four hours are required to decompose a kettle of 11,000 pounds.

Considerable quantities of hydrogen gas are formed during the treatment of the zinc, and if the tightly-closed hoods are opened and air allowed to enter before the end of the operation, there is danger of an explosion. This risk may be avoided by conducting through the hood a second steam-pipe to discharge above the bath of metal and thus passing steam over the kettle and through the condensation chamber after the conclusion of the process.

The completion of the operation is recognized by means of samples of the oxides and the rich lead. The latter must be so free from zinc that no flaps remain on a ladle from which it is poured, while the oxides must be in a fine powder, free from the greasiness of intermixed metal, and when taken in a glowing condition must exhibit no ignition of zinc in the air.

The smoke carried off with the steam consists, for the most part, of oxide of zinc, and is always more or less argentiferous, and it is, wherever practicable, advisable to erect sufficient condensation chambers to collect it.

According to Gruner, during an experiment of considerable duration, the loss of silver at Havre amounted to three per cent., an unfavorable result which must, in great part, have been owing to insufficient condensing chambers. The relative amounts of oxides and rich lead depend on the character of the zinc scum. In the Hartz, where, as already mentioned, the zinc scum is enriched to fifteen per cent., from 100 pounds of zinc scum are obtained on an average 70 to 75 pounds of rich lead; 32 to 26 pounds oxides.

As known, not only the silver, but the greater portion of the copper, with small quantities of antimony, is concentrated in the rich lead; and when treating lead containing much copper, the enrichment of the zinc must, on this account, not be carried too far, since the rich lead contains so much copper that it will hardly melt. In this case a very rich litharge is obtained from the cupellation of the rich lead, and a relatively very large portion of the silver must be returned to intermediate operations, causing a loss which is evidently a great disadvantage.

Final treatment.—The further treatment of the argentiferous oxides is an important question, and the following process is employed at the Havre works:

The oxides, in a fine powder, are separated from the intermingled grains, which consist, for the most part, of the very refractory alloy, by shifting under water. The grains are powdered in a mortar and then treated, like the fine powder, with hydrochloric acid, for the purpose of removing the zinc, which otherwise hinders the reduction of the oxides. Therefore, only so much acid should be used as to bring all the zinc into solution. When this end is completely attained, there is formed at the same time an insoluble oxychloride of lead. For this purpose cisterns are used at Havre, laid in Portland cement, and lined with a thick coating of the same, to protect them from the action of the acid. Iron vessels, enameled on the inside, resisted the action of the acid but a short time. To manipulate 44,100 pounds of lead daily, two cisterns 4 feet long in clear, 3 feet broad and 2½ feet deep, are sufficient for the treatment of the rich and poor oxides.

The cisterns are provided with a tap 1½ feet above the floor. Previous to dissolving, the oxides are stirred with a little water, and the acid added cold, as brought, without any further dilution. It is then stirred uninterruptedly from four to five hours, in order to prevent any caking together of the oxides, which would hinder the action of the acid. The operation is completed when a sample of the oxides melts in a crucible in a muffle-furnace without the addition of any fluxes. The greater portion must then separate as metallic lead. The oxychloride of lead, present in smaller quantities, forms a thin fluid slag over the metallic mass. Until this separation takes place completely, that is, so long as the slag of oxychloride of lead is still porous and appears mixed with particles of metal, zinc is still present and the process unfinished. If the fluid over the oxides reacts neutrally before the oxides gain the desired character, acid is wanting; but if with an acid reaction the oxides are sufficiently prepared, fresh quantities of oxides are added so as to utilize the acid completely. Acid reaction is shown by the evolution of hydrogen gas on dipping in a piece of zinc. In this way it is very easy to effect the entire removal of the zinc without the use of an excess of acid.

After tapping off the fluid into clearing vessels, the oxides so prepared are placed on an inclined plane to drain, and then melted in iron kettles, thus separating the greater portion of the rich lead from the chloride of lead containing little silver. The last is reduced in a reverberatory furnace with lime and coal. The slags formed in this are melted in a low blast-furnace with the dross obtained in the reduction of rich litharge in a reverberatory furnace, together with a flux of ferruginous substances. The result is a cupriferous matte containing but little lead, and slag lead, which is refined, and then goes back to the desilverization. The chloride is thrown aside as useless.

In considering the method just described, the amount of hydrochloric acid used forms a very important factor in the calculation, and this varies with the proportion of zinc present in the oxides. No accurate investigation on this subject has been made at Havre, but it may be predicted that the amount of acid used approximates to the amount of oxides treated, or about 2 per cent. of the original lead. At Havre the acid can be bought at the low rate of 50 cents per 100 pounds, costing about 1¼ cents per 100 pounds of lead treated. In the Hartz, where the price is much higher, this method was found impracticable. The rich oxides are there introduced at the highest possible heat during cupellation. To prevent loss from the formation of dust, the blast is shut off until the oxides form a pulpy mass on the surface of lead being cupelled; the blast is then let on again and the fire kept at high heat until a less-consistent pulpy slag has formed. This is drawn off, and consists of oxide of zinc, oxide of lead, and grains of rich lead. The silver contained in this scum does not amount to more than 23,750 grains in the ton, the greatest portion of the silver having passed into the lead. Afer the scum has been drawn off, true litharge is formed, which, from the high percentage of silver in the lead, is always argentiferous. As the grains of rich lead in the scum cannot be mechanically removed, (by washing or buddling,) the whole of the scum is reduced together with rich litharge. The zinc beihg present, not as metal, but oxide, does not injuriously affect the working of the furnace, as was the case formerly in smelting the zinc scum. As the zincous slags produced by the reduction still contain lead and some silver, they are therefore added to the matte smelting in a blast-furnace where a very thin, fluid slag, rich in iron, is produced, so that the zinc, which has no ill effect on the working of the furnace, is lost in the slags and thrown away.

A condition of success in the operation of adding oxides during the cupellation is, that the oxides must not be taken too dry, *i. e.*, too poor in lead, as in that case the amount of oxides produced is so great as to be disproportioned to the quantity of rich lead. It has been found, in relation to the silver and copper contained in the lead at Lautenthal, that it is advisable to take from 8 to 10 per cent. of the lead placed in the kettles in the form of zinc scum.

An inspection of table 1 will show that the rich oxides are utilized at a much less cost in the Hartz than at Havre, and by this process there is little danger of loss, provided the oxides are added with care during cupellation. It may, however, be recommended, where practicable, to supply the cupelling furnaces with condensation chambers. The method of decomposing the rich, argentiferous zinc scum by steam, and utilizing the oxides by addition during cupellation, is marked by its simplicity, its slight expense, and comparative freedom from loss.

The whole steam process, both for refining the poor lead and treating the rich oxides, is to be regarded as an essential improvement in zinc desilverization, which must lead to its general introduction.

Impure Desilverized Lead
(with Steam.)

Poor Zinc Scum
(washed.)

Soft Lead
(Mercantile Ar

Lead Particles.

Zinc Oxides, Rich in Lead
(reduced in Reverberatory Furnace.)

Lead.

Abstrich
(to be reduced in
Blast Furnace.)

Impure Desilver
(with Stea
Dezincized.

Oxides free from Silver
(with 50 to 60 per ct. Lead.
2.553 per ct., to be washed.)

Impure Desilv
(with Ste
Removal of A

Oxides
(containing 85 per ct. Lead,
1.733 per ct.)

Oxides
(containing 30 per ct. Lead,
0.82 per ct.)
(Paint.)

Mercantile Lead.

Reduced
(used 70 lbs. Coke.)

Desilverized Lead to be Refined
with Steam.
(6.713 per ct.,)
Used { 1,166 Bundles Brush,
43 lbs. Coal.

L
(0.
returned t

Good Pig Lead
(5.555 per ct.)

Antimonial Litharge
(0.533 per ct.)
To Matte Smelting.

Abstrich
(0.373 per ct.)
To be reduced.
Used, 63 lbs. Coke.

Re

A

In order to avoid returning the zinc to the smelting-furnace, as is the case when the oxides are added to the lead during cupellation, the attempt was made to separate, by washing, the oxide of zinc free from silver, from the mechanically inclosed argentiferous particles of lead; but a sufficient separation was found to involve too great expense, in consequence of the fine state of division of the mass, and that an oxide of zinc was produced too argentiferous to permit its entire removal.

A series of excursions in Germany during a period of three years, gave the translator opportunities carefully to observe and study all the methods of zinc desilverization in use. Of these he considers the Cordurié process decidedly the best and most economical. With local modifications, this method is suitable wherever the price of zinc is not exorbitant. Its great advantage over that of Pattinson is shown in the preceding article, and its general substitution is merely a question of time.

TABLE 1.—*Cost and production, with lead from the Upper Hartz; determined from the treatment of* 1,653,450 *pounds.*

I.—METAL PRODUCTION BY THE ZINC DESILVERIZATION.

Materials and products.	BY THE STEAM PROCESS. From the assay there is contained—		BY USE OF STASSFURTH SALTS. Amount used and obtained in per cent.—		BY POLING. Am't used and obtained in per cent.—	
	Silver.	Lead.	Silver.	Lead.	Lead.	Lead.
USED.						
	lbs. oz.	*lbs.*				
1,653,450 pounds lead from blast furnace	2,770 11	1,651,176	....	....	....	....
5,620 pounds lead from liquation of abstrich	6 10	5,616	....	....	....	....
Total	2,777 9	1,656,792	100	100	100	100
PRODUCED.						
(*A*)—*Mercantile products.*						
2,911,145 cupelled silver	2,721 11	....	97.99	....	....	....
Refined Hartz lead	....	1,398,490	....	83.202	77.187	74.57
Good pig-lead	....	91,844	....	5.543	12.120	15 40
Antimonial lead	....	22,067	....	1.332	12.120	15.40
Oxides containing no silver, (13,560 pounds, containing, by assay, 30 per cent. lead.)	....	4,067	....	0.246	12.190	15.40
Total A	2,721 11	1,516,468	97.99	90.323	89.307	87.97
(*B*)—*Subordinate products returned to smelting processes.*						
50,926 pounds antimonial litharge, with per 100 pounds 1.096 pounds silver.	55 8	50,881	....	....	....	....
17,306 pounds sole of cupelling furnace with per 100 pounds 12.1 pounds silver and 66 pounds lead.	2 1	11,460	....	....	....	....
35,714 pounds flux, containing lead, with per 100 pounds .060 pounds silver and 90 pounds lead.	2 2	32,143	....	....	....	....
12,125 pounds lead dross with per 100 pounds 94 pounds lead.	....	11,397	....	....	....	....
36,706 pounds lead slugs per 100 pounds 14 pounds lead.	....	5,140	....	....	....	....
Total B	59 11	111,021	2.159	6.701	7.373	6.87
Total A and B	2,871 10	1,627,489	100.149	97.024	96.680	96.84
Hence, with regard to the metals used, gain	4 1	....	0.149	....	....	....
Hence, with regard to the metals used, loss	....	29,303	....	2.976	3.390	3.16

II.—COST OF THE ZINC DESILVERIZATION.

For 5½ tons of lead.	By the steam process.			By use of Stassfurth salts.
	Wages.	Materials.	Total.	Total per 110 pounds lead.
Desilverization; Dezincation; Removing antimony by steam; Decomposition of zinc-scum	$2 76	$11 60	$14 36	15 cents.
Refining the desilverized lead	....	....	....	4 cents.
Reduction of the zinc-scum	....	....	....	4 cents.
Cupellation	80	1 50	2 30	2 cents.
Reduction of the oxides formed by cupellation	38	1 11	1 49	2 cents.
Washing the oxides free of silver	29	14 00	29	....
Reducing the litharge	14	22	36	....
Refining desilverized lead from reduction	8	13	21	....
Preparation of antimonial lead	7	19	26	1 cent.
Total	4 52	14 75	19 27	....
Therefore for 110 pounds lead	5	13	18	28 cents.
Expenses for smithing, oil, grease, kettles, &c., per 110 pounds lead.	....	....	5	....
Total all costs, except superintendent's pay	....	....	23	33 cents.

LEAD AND SILVER SMELTING IN SAN FRANCISCO.

The largest lead and silver smelting-works in the United States, at the present time, are undoubtedly those of Mayor Selby, in San Francisco. The Bulletin, of that city, published lately an interesting article in regard to them, which I give in full:

We have in San Francisco the most extensive smelting-works in the United States, which have been quietly growing up during the last four years, in a remote part of the city nd almost unknown beyond the large number of workmen immediately engaged, and the mining and freighting interests which are employed in furnishing ores and crude bullion. We refer to the lead and silver-smelting works of Mayor Selby, near Black Point, an establishment of the first importance as a means of developing the mines of the Pacific coast, and with reference to the value of its transactions. These works, which we have recently visited, consume the great majority of all the ore and crude bullion shipped to San Francisco, and they are being constantly increased in extent to keep pace with the expansion of the industrial interests with which they are associated. Their present capacity can be enlarged to an unlimited extent; but even now the quantity of crude bullion and ore consumed exceeds that of any other lead and silver smelting-works in the country—probably working up twice the amount used by the Newark Reduction Works, which, at one time, were considered the largest in the United States.

The legitimate place for smelting the ore would seem to be at the mines from which they are extracted; but as they can be more advantageously worked where science, skilled labor, and capital are concentrated, as at the sea-board cities, the nearest and most available locality is undoubtedly San Francisco. From the mines of Nevada and Utah to this city the distance is so small, compared with that to the Atlantic States, as to constitute the former the natural customer for their ores, rendering successful competition from the East out of the question. And we propose to show that in our city the facilities for smelting are superior to what are offered in any other locality. The small shipments of ores which, upon the opening of the Pacific Railroad, went East as experiments, soon established these facts, as well as that higher rates are paid at the smelting-works here than can be obtained elsewhere in the United States, while the cost of transportation is at least a half less in favor of San Francisco, to say nothing of the considerable percentage of ore that is lost by car-shifting and the jolting and sifting incident to so long a transit.

Some of the shippers who for a while gave Newark a trial, soon became satisfied of this, and are now again sending their ores to San Francisco, not only because the work is done cheaper here and the charges are less, but the treatment is more thorough and consequently the yield greater. This same rule as to cheapness applies to ores that have been shipped to Swansea for reduction, and there is this additional fact in connection with that market, that while miners complain of not receiving fair returns

from Swansea, experience has shown them that at Mr. Selby's works they are honorably and promptly paid.

As regards the time consumed in the treatment of ores, miners will find that the advantages, on account of the late improvements, will be largely in favor of San Francisco, and that returns will be made with very little delay. The rule adopted by Mr. Selby is to buy the ores, which is conveniently done, owing to the extent of his connections and agencies throughout the mining region. The works are always ready to pay shipping expenses on ore from anywhere, and meet freight bills promptly on all kinds, the bills of all kinds following the metal.

Although a large and increasing amount of ore is received at the works from Nevada and Utah, they are by no means dependent on those States for their supply, which arrives from about every important lead and silver locality on the Pacific coast, including the distant mining regions of New Mexico, Arizona, Mexico, and along the Colorado River, whence they are brought by sea via the Gulf of California. No crude bullion nor ores are refused, unless the latter are of too low a grade to admit of profitable reduction. In the early history of the enterprise, ores for a while came too fast for the extent of the works; but with the present enlarged facilities it would be difficult to overtask their capacity, which can at short notice be increased so as to meet any demand likely to be made on them in the future. They were originally designed by Mr. Selby, in joint interest with his New York partner, Mr. P. Naylor, (now on his first visit to California during a business association of twenty years,) for the purpose of supplying their shot-tower in this city with lead. The idea of manufacturing for Eastern markets, or for exportation, had not then been entertained. For years the experiment was a failure, financially, and a less persistent man than Mr. Selby would have abandoned the enterprise. Costly experiments were necessary, and heavy expenditures attended the enterprise before returns began to be realized. The result is the most important lead and silver smelting establishment in the country, employing, directly and indirectly, more than a thousand men in the various callings with which it is associated. It is the friend of the workingman, for whom it acts as a reliable bank of deposit, and whose labor it converts into ready cash on demand.

The location of the works, which occupy four fifty-vara lots, is on Jefferson street, at the northern extremity of the city, on a point of land projecting into the bay opposite Fort Alcataraz, and at the northern terminus of Montgomery avenue, that is to be. On the bay there is ample wharf frontage, with depth of water sufficient to accommodate the vessels engaged in bringing ores and crude bullion to the works, and carrying away lead and silver. This bulkhead wharf is being steadily pushed out into the bay by the accumulations of slag and other matter, real estate being thus increased at a rapid rate. A railroad for hand-cars extends through the works to the water front, serving the double purpose of conveying market lead to the vessels at the wharf, and for dumping the refuse collections at the bulkhead. The works, which are indicated from a considereable distance by a large stack, are approached by a plank road laid through the sand drifts which here reach nearly to the shores of the bay. Formidable notices of "No Admission," posted over the gateway, remind one that the inmates are supposed to know how to keep their own counsel.

The entire works are under the general supervision of Prentice Selby, a son of the proprietor, who, from the beginning, has aided in bringing them to their present state of efficiency, and who has recently returned from a short visit to examine the smelting facilities in the Atlantic States—a tour of inspection, which, it may be added, showed that the business as conducted in San Francisco is far in advance of any Eastern competition. The immediate superintendent, W. R. Thompson, who entered upon his duties when the works were yet in an experimental condition, explained to us in detail the various processes. We do not propose to risk confidence by an attempt at description. Suffice it to generalize by stating that the ore, landed at the wharf, is brought by railroad into the works, where it is crushed, sampled, and prepared for calcining; thence it goes to the blast-furnace to be smelted; thence to the refining furnaces, where it is cleared of its base matter; thence to the desilverizing furnaces, which separate the silver from the lead. Here it "splits" and takes two directions—the lead going to the refining furnace again, where it is converted into market lead, is stamped with the proprietor's name, and is piled away ready for shipment. The residue from the desilverizing furnace goes back to the smelting and thence to the cupel furnace, where the small percentage of lead still remaining is extracted, leaving the silver pure, or nearly so. This is melted again in crucibles to still further refine it; for although it comes from the cupel-furnace 990-1000 fine, which is suitable for the purposes of the mint, it is not fine enough for shipment to China, where the standard required is 996-1000. The perfection to which this art may be brought is shown in one lot of 10,000 ounces, which assayed nine hundred and ninety-nine and three-tenths one thousandths fine.

Upon entering the works, the visitor is impressed with their extent and the amount of business transacted. A powerful engine carries the blast to the furnaces and drives the crushing-mill; and far and near, through the smoke, the heat of intense fires, the clash of iron implements, the glare of furnaces, and the clank of machinery, indicate a

hive of industry, where science and labor are intelligently combined to unlock the treasures of the mine to the purposes of trade and commerce. Everywhere the attention is called to interesting and instructive processes. In one furnace we are shown about 6,000 ounces of melted silver. From others liquid lead is being ladled into molds placed in rows ready to receive it. Beyond, a stream of red-hot litharge is being run from a cupelling furnace. In another direction pyramids of pigs of crude bullion are being carefully sampled, by clipping off with chisels pieces from the corners and edges. Further on a gang of men are piling up 1,200 pigs of market lead, weighing 115 pounds each, the result of one week's work. In a huge iron safe are stored quantities of silver in sheets and heavy fragments, ready for transportation to the United States Mint. Near one of the desilverizing furnaces is piled a mass of silver "dross" (the residue which has been separated from the lead, and carrying from 1,200 to 1,500 ounces of silver to the ton) awaiting the process of the cupel furnace. The lead, after each smelting, is run into pig-molds, and is conveyed to the successive furnaces by a system of miniature railroads, branching off in all directions to distant parts of the works.

Following our conductor, we enter the assaying department, where exist all the most approved modern appliances for dispatch and accuracy. This department is a scene of scientific industry, in which many interesting experiments are made in furtherance of the object of the works.

Situated over the main works, and reached by an inclined road, is an extensive platform on which are collected and arranged the various substances which are fed down as fluxes into the smelting-furnaces below, in quantities as required—such as scraps and cuttings of iron and other metals, lime, and a general mixture of the by-products of the works—dross, agglomerated ore, &c., which are worked over and made to serve a profitable purpose.

The remarkable success now attending the works was only reached through years of heavy outlay and careful study. The idea that smelting is a simple affair, requiring only the throwing in of the ore and the running out of the metal, is effectually dispelled after an examination of the intricate process—the skill and experience required in the business. To an uninitiated spectator there is a strange fascination in these rills of liquid silver pouring from flaming furnaces—these pools of molten lead confined within margins of white-hot masonry and reflecting like mirrors the delicate and ever-changing colors produced by the mysterious action of heat and chemicals. In these smelting-works fourteen furnaces are kept constantly employed, and that number will be doubled as the supply of ore increases.

The most valuable ores are received from Arizona, and localities too remote from any Eastern market to admit of shipment there, even were it desirable. The works take, without hesitation, all available ores that are offered. One firm in the neighborhood of Salt Lake have received $40,000 for ores shipped by the Pacific Railroad. Another located in the southern part of this State has been paid upwards of $100,000 for lead bullion. So extensive has the business become under the intelligent management of Mr. Selby, that his works have stopped the importation of lead to the Pacific coast as effectually as his shot-tower has driven all other shot out of the market; although in both enterprises he commenced against heavy Eastern competition and with the general prediction that the attempt would prove a failure.

Not only have the works grown into the largest producer of lead in the United States, (of which the shipment to Mr. Naylor in New York, will this year be 1,200 or 1,500 tons, constituting a valuable item in our home industry,) but they are yielding silver bullion at the rate of $30,000 per month, which is extracted from the lead, all resulting from the enterprise of one firm, and redounding largely to the credit of California. The growth of this branch has been such that furnaces especially for smelting gold and silver ores are about to be erected. These will also work up the jewelers' and mint sweepings, which, in the long run, is a substantial item; and there is no reason why the smelting of copper and tin ore should not be successfully carried on at the same establishment, which, if its transactions continue to increase as rapidly as they have done for the few years past, seems likely to rank with the well known ones of England, Wales, and Germany.

While the yield of all other branches of mining on the Pacific coast has declined, that of lead mining has steadily increased, under the encouragement created by the persistent energy of one firm. Of the 30,000 tons of lead now annually used in the United States, less than 20,000 tons are produced in our own country. Statistics show that the home product has been lessening since 1862, while the annual consumption, and consequently the importation from foreign countries, is largely increasing. Thus, there is no danger of overstocking the market. The above amount, annually consumed in our country, is used in a multitude of ways; for lead pipe, lining of tubs, vats, etc.; soldering, preparing chemicals and dyes; bullets, type-metal; weights, plumbing for houses, steamships, etc.; pipe and sheet lead and shot, of which 12,000,000 pounds—and paints, including white lead, of which no less than 40,000,000 pounds—are annually manufactured and used in the United States.

CHAPTER XVI.

LIST OF STAMP-MILLS.

The following list is based upon that in Langley's excellent "Pacific Coast Directory." Many alterations have been made, however, and several districts, and two whole Territories, are represented by entirely new lists, prepared without reference to Langley's. Indeed, his catalogue does not include Colorado at all; and his list of mills in Montana has been complained of by the press of that Territory as not sufficiently modern. The chief criticism of the newspapers upon it, however, will be equally applicable to the very full and complete list of Montana stamp-mills which I present, namely, there is no distinction made between the mills now running and those standing idle. The citizens naturally do not like, on the one hand, to confess that the majority of the stamp-mills are idle, nor, on the other hand, to have the comparatively small amount of gold produced from quartz charged to so large a number of mills. The truth is that Montana quartz-mining is still a subordinate industry, compared with the working of gulches and placers, though it will undoubtedly become the more important industry of the two, when the Northern Pacific Railroad shall have opened the Territory to cheap labor and freights. The idle mills will then find opportunity for profitable activity.

I may say in general of the following list, that it does not pretend to distinguish between works now running, and those which are either temporarily or permanently closed, except when such a statement is explicitly made. The quotations from the census returns, however, refer (if the assistant marshals have followed the instructions they received) to establishments in operation during some part of the year ending June 1, 1870.

It is possible that in attempting to combine the data afforded by personal observation, official reports, private correspondence, the census, and Mr. Langley's catalogue, some errors have been committed, in consequence of the different names frequently attached to the same establishment. The danger of such mistakes has, however, been constantly kept in view, and guarded against, so far as the nature of the case would permit; and it is believed that the list here presented is the most comprehensive and accurate that has been published up to the present time.

List of quartz mills, with the location, name of mill, date of erection, number of stamps, cost of machinery, and the director's or owner's name of each.

CALIFORNIA.

Location.	Name of mill.	When erected.	No. of stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
ALPINE COUNTY.								
Markleville	Pioneer	1863	10	..	Steam.	$50,000	Silver	Jones, Wade & Co.
Silver Mountain	Silver Creek	1866	..	..	Water.	36,000	..do	D. Davidson.
Silver Mountain	Star	1864	6	..	..do	15,000	..do	Pittsburg Company.
AMADOR COUNTY.								
Amador City	Amador	1856	10	..	Steam.	10,000	Gold	Jno. A. Faull & Co.
Amador City	Fleehart's	1866	10	..	..do	10,000	..do	A. Hayward.
Amador City	Hazard	1857	8	..	Water.	6,000	..do	Do.
Amador City	Keystone	1856	40	..	Steam.	80,000	..do	Gashweiler & Co.
Amador City	Spring Hill	1856	40	..	S. & W.	40,000	..do	Do.
Clinton	Rocky Falls	1865	10	..	Steam.	10,000	..do	Henry D. Bacon.
Clinton	Union	1858	10	..	..do	10,000	..do	E. P. Steen.
Drytown	Plymouth	1860	20	..	S. & W.	20,000	..do	Plymouth Mining Co.
Drytown	Potosi	1857	16	..	Water.	10,000	..do	W. H. Hooper & Co.
Fiddletown	Richmond	1865	10	..	S. & W.	10,000	..do	Philadelphia Co.
Jackson	Casco	1869	12	..	Water.	10,000	..do	Haley & Hardenburg.
Jackson	Kennedy	1868	16	..	Steam.	12,000	..do	Kennedy Mining Co.
Jackson	Kearsings	1862	10	..	Water.	5,000	..do	Kearsing Bros.
Jackson	Oneida	1857	60	..	Steam.	100,000	..do	Oneida Mining Co.
Jackson	Tubbs's	1866	10	..	..do	10,000	..do	Tubbs & Co.
Jackson	Zeile Mining Co	1264	16	..	..do	10,000	..do	Zeile Mining Co.
Pine Grove	Tellurium	1864	10	..	..do	10,000	..do	Ryder & Co.
Sutter Creek	Badger	1858	16	..	Water.	10,000	..do	Amador Mining Co.
Sutter Creek	Downs	1858	10	..	..do	10,000	..do	R. C. Downs.
Sutter Creek	Eureka	1869	40	..	S. & W.	100,000	..do	Amador Mining Co.
Sutter Creek	Lincoln Quartz M. Co	....	20	..	..do	10,000	..do	R. C. Downs, sup't.
Sutter Creek	Mahoney	1859	16	..	Water.	15,000	..do	Mahoney Brothers.
Sutter Creek	Rose's	1866	16	..	..do	20,000	..do	Amador Mining Co.
Sutter Creek	Wildman's	1859	12	..	..do	10,000	..do	C. T. Wheeler.
Volcano	Belding	1865	10	..	S. & W.	12,000	..do	California Furnace Co.
Volcano	Eagle	1858	10	..	..do	9,000	..do	—— Pine, sup't.
Volcano	Fogus	1865	10	..	Water.	10,000	..do	Woodcock & Co.
Volcano	Golden Gate	1865	10	..	S. & W.	20,000	..do	P. A. Clute.
Volcano	Italian	1862	10	..	Water.	8,000	..do	Rose & Co.
Volcano	Mitchell's	1863	20	..	..do	20,000	..do	McLane & Sirocco.
Volcano	Monday	1860	10	..	..do	4,000	..do	Fogus & Co.
Volcano	Pioneer	1855	10	..	S. & W.	15,000	..do	L. R. Poundstone.
Volcano	Sirocco	1860	20	..	..do	20,000	..do	McLane & Sirocco.
Volcano	Sulphuret	1864	5	..	..do	9,000	..do	H. Schultz.
Volcano	Tulloch	1865	15	..	Steam.	8,000	..do	Lawton & Co.
Volcano	Tynan	1865	12	..	..do	8,000	..do	Marklee & Co.
BUTTE COUNTY.*								
Cherokee Ravine	Binney & Co's	1866	4	..	Water.	3,000	Gold	Binney & Co.
Enterprise		1867	4	..	..do	5,000	..do	Kerns & Mayoux.
Enterprise	Leviathan	1868	4	..	..do	5,000	..do	Perkins & Co.
Enterprise	Trojan	1868	8	1	Steam.	10,000	..do	E. W. Slater & Co.
Forbestown	Forbestown	1866	5	..	..do	5,000	..do	J. W. Riant.
Jordan Hill	Porter Mining Co	1865	12	1	..do	20,000	..do	E. C. Ross & Co.
Nimshew		1868	..	2	Water.	....	..do	Jones.
Oregon City	Cambria	1866	5	..	Steam.	12,000	..do	C. A. Halstead.
Oregon City	Nisbet	1865	8	..	..do	15,000	..do	Nisbet & Co.
Oregon Gulch	Smith & Sparks's	1856	12	1	..do	30,000	..do	Oroville G. & S. M. Co.
Oregon Gulch		1868	..	1	Water.	....	..do	Grummet & Stempel.
Oregon Gulch		1868	..	1	..do	....	..do	W. S. Reese.
Swede's Flat	Merrimac	1868	10	..	Steam.	10,000	..do	Warren & Co.
CALAVERAS COUNTY.*								
Altaville	Altaville Q. M. Co	1863	16	..	Water.	15,000	Gold	Larco, Prince & Co.
Angel Creek	Angel Creek	1865	6	..	..do	....	..do	Spence & Co.
Angel's Camp	Angel's Q. M. Co.	1862	30	..	Steam.	40,000	..do	Angel's Q. M. Co.
Angel's Camp	Billings	1868	3	..	Water.	....	..do	E. Billings.
Angel's Camp	Doe & Brother	1860	10	..	Steam.	10,000	..do	Doe & Brother.
Angel's Camp	Larco & Co	1863	10	..	Water.	....	..do	N. Larco & Co.
Angel's Camp	Stickles & Co	1866	10	..	..do	5,000	..do	Stickles & Co.

*** The list of mill reported in June, 1870, to the Census Bureau, differs somewhat from this, both in the number of mills and in the number of stamps, but the carelessness of clerks in regard to names of owners (not to be published in the census) renders detailed comparison impossible.**

List of quartz mills, &c.—Continued.

CALIFORNIA.

Location.	Name of mill.	When erected.	No. of stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
CALAVERAS CO.—Con.								
Carson's	Finigan & Co	1866	6	..	Steam.	$50,000	Gold ..	Finigan & Co.
Carson's	Stevenot	1864	15	..	Water.	....	..do ...	G. K. Stevenot.
Carson's	Union Quartz Co.	1865	20	..	Steam.	30,000	..do ...	Union Quartz Co.
Cherokee Flat	Cherokee	1860	10	..	..do ...	3,000	..do ...	Cherokee Mining Co.
Copperopolis	Duncan's	1865	10	..	..do ...	15,000	..do ...	Duncan & Co.
Dry Creek	Dry Creek	1862	10	..	..do ...	10,000	..do ..	Knox & Co.
El Dorado	El Dorado	1866	10	..	..do ...	10,000	..do ...	William Irvine.
Lower Rich Gulch	Alexander's	1866	10	..	Water.	5,000	..do ...	Alexander & Co.
Lower Rich Gulch	Coloma	1869	36	..	..do ...	45,000	..do ...	Gwin & Colman.
M. F. Mokelumne Riv	Carlton's Arastras	1860	3	2	..do ...	200	..do ...	B. F. Carlton.
Mosquito	Musquito Q. M. Co.	1863	15	..	Steam.	15,000	..do ...	Cutter & Waters.
Railroad Flat	Hepburn & Co	....	10	..	..do ...	8,000	..do ...	Hepburn & Co., and Burr & Co.
Railroad Flat	Lewis & Brother	1870	5	..	..do ...	5,000	..do ...	Lewis & Brother.
Railroad Flat	Petticoat	....	10	..	..do ...	20,000	..do ...	G. W. Hopkins.
Rich Gulch Flat	Clerc & Co's	....	15	..	..do ...	16,000	..do ...	Clerc & Co.
San Andreas	Rathgeb's	1864	10	..	Water.	7,000	..do ...	John Rathgeb.
Sandy Gulch	Woodhouse	1858	15	..	..do ...	15,000	..do ...	C. Smith.
Skull Flat	Tacatero	1859	10	..	..do ...	3,000	..do ...	Gaune & Co.
West Point	Harris's	1860	5	..	..do ...	3,000	..do ...	A. Harris.
West Point	Hope's	1860	15	..	..do ...	15,000	..do ...	—— Hope.
West Point	Lacey's	1861	5	..	..do ...	41,000	..do ...	A. Lacey.
West Point	Vance's	1862	10	..	Steam.	15,000	..do ...	—— Bernard.
West Point	William H. Thoss	1864	5	3	Water.	6,000	..do ...	William H. Thoss.
	Thorpe & Co	....	..	2	....	....	....	Thorpe & Co.
EL DORADO COUNTY.*								
Cold Springs	Columbus	1866	..	..	Water.	....	Gold ..	J. C. McFarnahan, s't.
Coloma	Isabell G. & S. M. Co.	1864	5	..	..do ...	6,000	..do ...	Philo Isabell, sup't.
Cosumnes	Stillwagon & Norton	1866	4	..	..do ...	1,500	..do ...	Stillwagon & Norton.
Cosumnes	Tulloch & Ault	1866	8	..	Steam.	4,000	..do ...	Tulloch & Ault.
Diamond Springs	Cooke's†	1866	5	..	Water.	1,000	..do ...	J. Cooke & Co.
El Dorado	Fort Yuma	1864	..	2	Steam.	....	..do ...	....
El Dorado	Havilah	1868	40	..	Water.	25,000	..do ...	—— Perkins, sup't.
El Dorado	Logtown	1856	15	..	Steam.	9,000	..do ...	Pocahontas G. M. Co.
El Dorado	Montezuma	1866	20	..	Water.	60,000	..do ...	—— Richmond, agent.
El Dorado	N. Y. & El Dorado	1865	18	..	Steam.	20,000	..do ...	N. Y. & El Dorado Co.
El Dorado	Sugar Loaf	1866	20	..	..do ...	15,000	..do ...	C. McGuire, sup't.
El Dorado	Union	1865	20	..	..do ...	12,000	..do ...	W. E. Church, sup't.
El Dorado	Wilder	1865	8	..	Water.	2,500	..do ...	B. W. Wilder.
Georgetown	Clipper G. & S. M. Co	1863	5	..	..do ...	12,000	..do ...	R. Cushman, sup't.
Georgetown	Woodside	1863	2	..	Steam.	6,000	..do ...	Ash, Lane & Knox.
Georgia Slide	Blue Rock	1866	10	..	Water.	1,000	..do ...	John Hines & Co.
Grizzly Flat	Eagle	1866	20	..	..do ...	12,000	..do ...	William Bigler.
Grizzly Flat	Mount Pleasant	1867	20	..	Steam.	60,000	..do ...	O. D. Lombard.
Lyonsdale	Blue Ledge	1864	2	..	..do ...	60,000	..do ...	A. M. Stetson, sup't.
Kelsey	Plymouth	1864	15	..	Water.	....	..do ...	—— Potter, sup't.
Placerville	Harmon	1866	15	..	Steam.	20,000	..do ...	Harmon G. & S. M. Co.
Placerville	Jess's	1870	10	..	Water.	1,500	..do ...	W. F. Jess.
Placerville	Loafer's Hollow	1866	10	..	Steam.	12,000	..do ...	C. W. Moulthrop, s't.
Placerville	Lyon	1870	10	..	..do ...	2,500	..do ...	H. L. Robinson, sup't.
Placerville	Manning	1864	4	..	..do ...	5,000	..do ...	Blain, Alderson, & Co.
Placerville	New York	1862	20	..	..do ...	10,000	..do ...	F. Reed.
Placerville	Pacific	1857	10	..	..do ...	15,000	..do ..	J. M. Douglass.
Placerville	Poverty Point	1864	10	..	..do ...	8,000	..do ...	Burdick & White.
Placerville	Rising Hope	1870	10	..	..do ...	2,500	..do ...	J. Blair.
Placerville	Shepherd's	1870	10	..	..do ...	3,000	..do ...	Shepherd & Witten.
Placerville	U. S. Grant	1870	10	..	..do ...	2,300	..do ...	....
Shingle Springs	Gray's	1863	10	..	..do ...	1,500	..do ...	Gray Bros. & Son.
Smith's Flat	Brewster & Co's†	1866	12	..	Water.	6,000	..do ...	Brewster & Co.
Smith's Flat	Hook and Ladder†	1866	4	..	..do ...	500	..do ...	Anderson & Redd.
Smith's Flat	Taft's†	1860	10	..	Steam.	2,000	..do ...	P. M. Taft.
Soap Weed	Cobb & Co	1866	12	..	Water.	4,000	..do ...	Cobb & Co.
Texas Hill	Stewart's†	1866	10	..	..do ...	3,000	..do ...	Stewart & Hall.
Volcanoville	French	1859	20	..	Steam.	40,000	..do ...	French Company.
White Rock	Live Oak†	1866	8	..	Water.	2,000	..do ...	Ward Bros.
	Dead Broke	1870	..	1	..do ...	500	..do ...	Burlingham & Jayco.

* The list of mills reported in June, 1870, to the Census Bureau, differs somewhat from this, both in the number of mills and in the number of stamps, but the carelessness of clerks in regard to names of owners (not to be published in the census) renders detailed comparison impossible.

† Cement mills.

List of quartz mills, &c.—Continued.

CALIFORNIA.

Location.	Name of mill.	When erected.	No. of stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
FRESNO COUNTY.								
Coarse Gold Gulch	Texas Flat	1865	8	2	Steam	$5,000	Gold	—— Rogers.
Fine Gold Gulch	Hubert's	1868	10	2	..do	7,000	..do	N. Hubert.
Froelich's Creek	Bennett's	1866	10	2	..do	5,000	..do	Casper Bennett.
INYO COUNTY.*								
Cerro Gordo	Belshaw's Furnace	1868	..	..	Steam	20,000	Silver	M. W. Belshaw & Co.
Chrysopolis City	Oro Fino	1866	20	..	Water	35,000	G & S	New York Co.
Fish Springs	McMurry's	1867	..	2	..do	1,000	Gold	J. W. McMurry.
Fish Springs	Westerville's	1867	..	2	..do	1,000	..do	J. R. Westerville.
Kearsarge District	Benway & Co	1866	5	..	..do	10,000	G & S	Benway & Co.
Kearsarge District	Kearsarge Co	1866	20	..	Steam	50,000	..do	Kearsarge Co.
Little Pine Creek	Silver Sprout	1866	5	..	Water	10,000	..do	Silver Sprout Co.
Lone Pine	Wolfskill & Co	1869	5	..	..do	14,000	Silver	Wolfskill & Co.
Owen's River	Eclipse	1870	6	..	Steam	50,000	G & S	Eclipse Mining Co.
Owen's River	Ida	1863	10	..	..do	10,000	Gold	Ida Mining Co.
Owen's River	San Carlos	1863	5	..	..do	20,000	..do	San Carlos Co.
Swansea	Owen's Lake S. L. Co	1869	..	..	..do	25,000	Silver	Owen's Lake S. L. C.
KERN COUNTY.†								
Erskine Creek	Erskine Creek	1866	..	4	Water	5,000	Gold	Erskine Creek Co.
Greenhorn	Alpine G. M. Co	1866	24	..	Steam	30,000	..do	W. F. White & Co.
Havilah	Howe & Oder's	1865	10	..	..do	16,000	..do	Howe & Co.
Havilah	Loyola	1864	10	..	..do	22,000	..do	H. McKeadney.
Havilah	N. Y. & Cl'r C'k M. Co	1866	10	..	..do	22,000	..do	N. Y. & Cl'r C'k M. Co.
Havilah	Rand & Co's	1865	10	..	..do	16,000	..do	A. A. Rand & Co.
Havilah	Wells, Fargo & Co's	1866	6	4	Water	17,000	..do	Wells, Fargo & Co.
Kernville	Big Blue G. & S. M. Co	1864	12	..	..do	40,000	..do	Big Blue G. & S. M. Co.
Kernville	Mammoth	1866	20	..	..do	45,000	..do	Mammoth G. M. Co.
Long Tom	Long Tom	1865	10	..	Steam	20,000	..do	Tucker & Co.
Sageland	Esperanza	1869	10	..	..do	5,000	..do	Esperanza Mining Co.
Sageland	St. John M. Co	1868	10	..	..do	12,000	..do	Thomas Bridger & Co.
Walker's Basin	Joe Walker M. Co	1866	20	..	..do	25,000	..do	Joe Walker Mining Co.
KLAMATH COUNTY.								
Big Bend, Salmon Riv.	Abrams & Co's	1868	..	1			Gold	Abrams & Co.
Black Bear Gulch	Black Bear	1862	12	..	Water	25,000	..do	Dagget, Coughlin & Co.
Eddy's Gulch	Klamath	1864	12	..	Steam	18,000	..do	A. Swain & Co.
Eddy's Gulch	Live Yankee	1861	8	..	Water	17,000	..do	John S. Reed & Co.
Jackass Gulch	Lone Star	1870	8	..	..do	13,000	..do	A. Myers.
LOS ANGELES COUNTY.								
Soledad	Eureka	1868	10	2	S. & W.	20,000	Gold	Hayward, Clark & Glease.
Soledad		1869	5	..	Water	10,000	..do	Downey & Co.
MARIPOSA COUNTY.								
Agua Fria Creek	Hambleton's	1857	4	1	Water	2,000	Gold	J. Hambleton.
Agua Fria Creek	Neal's	1869	4	1	..do	4,000	..do	J. H. Neal.
Bear Creek	Bobbio's	1865	4	2	..do	4,000	..do	Juan Bobbio.

* The Census Report of 1870 contains the following additional arrastras in this county:

Present occupants.	No. of arrastras.	Power.	Gold or silver.
Peduck & Co	3	Water	Gold.
Bares, Jesus	3	.. do	Do.
Ganiz, Jesus	1	Horse	Do.
Larger, Jno	3	Water	Do.
Decido, S	2	. do	Do.
Raex, Antonio	1	Horse	Do.

† The Census Report contains the mill of the Delphi Mining Company, with ten stamps, driven by steam power, and that of the Kern River Mining Company, with sixteen stamps and one crusher, also moved by steam, neither of which I can identify in the above list.

List of quartz mills, &c.—Continued.

CALIFORNIA.

Location.	Name of mill.	When erected.	No. of stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
MARIPOSA CO.—Con.								
Bear Creek	Chittenden's	1864	8	1	Water.	$10,000	Gold ..	George Chittenden.
Bear Valley	Bear Valley	1855	10	2	Steam.	20,000	..do ...	Mariposa Co.
Bondurant	Heslep's	1866	10	..	..do ...	10,000	..do ...	Heslep Co.
Bondurant	Shimer & Co's	1863	10	..	..do ...	12,000	..do ...	Shimer & Co.
Buckeye	Wilcox's	1870	8	..	..do ...	3,000	..do ...	J. W. Wilcox.
Buffalo Gulch	Feliciana Vein	1865	5	3	..do ...	6,000	..do ...	L. Trabucco.
Chimesal	Robinson & Co's	1861	10	..	..do ...	4,000	..do ...	Robinson & Co.
Gentry's Gulch	Coward's	1860	10	2	..do ...	25,000	..do ...	H. G. Coward.
Hite's Cove	Hite's	1863	8	4	Water.	22,000	..do ...	Hite & McDermit.
Hornitos	Hornitos G. & S. M. Co	1860	20	..	Steam.	30,000	..do ...	Hornitos G. & S. M. Co.
Mariposa Creek	Francis	1856	10	2	Water.	4,000	..do ...	Charles Francis.
Mariposa Creek	Mariposa	1864	50	..	Steam.	82,000	..do ...	Mariposa Co.
Maxwell Creek	Maxwell G. & S. M. Co	1864	40	..	..do ...	60,000	..do ...	Maxwell G. & S. M. Co.
Merced River	Ophir Mills, (3)	1858	65	..	Water.	120,000	..do ...	Mariposa Co.
Merced River	Ferguson's	1861	8	2	..do ...	6,000	..do ...	E. Ferguson.
Mount Gaines	Mount Gaines	1862	10	2	Steam.	13,000	..do ...	J. Spaguoli.
Mount Ophir	Mount Ophir	1858	24	..	..do ...	95,000	..do ...	Mariposa Co.
North Fork Merced R	Clark, Derrick & Co's	1857	10	..	..do ...	7,000	..do ...	W. W. Kelton.
Princeton	Princeton	1860	24	3	..do ...	40,000	..do ...	Mariposa Co.
Snow Creek	Buckingham Mount.	1869	5	1	Water.	5,000	..do ...	G. Bernhard.
Split Rock	Crown Lead Co	1863	20	..	Steam.	20,000	..do ...	Crown Lead Co.
Stockton Creek	Mariposa Co	1858	8	2	Water.	6,000	..do ...	Mariposa Co.
Sweetwater	Malone's	1863	12	..	Steam.	8,000	..do ...	James Malone.
Temperance Creek	Barrett's	1860	4	..	..do ...	5,000	..do ...	Joseph Barrett.
Temperance Creek	Lafayette M. Co	1866	4	..	..do ...	5,000	..do ...	Lafayette M. Co.
Whitlock's	Cunningham's	1863	12	2	Water.	22,000	..do ...	L. Cunningham.
MONO COUNTY.*								
Bodie	Empire	....	16	..	Steam.	130,000	Silver.	Empire M. & M. Co.
Hot Springs	Williams's	....	4	..	Water.	2,500	..do ...	A. B. Williams.
NEVADA COUNTY.†								
Bloomfield	Eureka M. & M. Co	....	5	..	....	....	Gold ..	Eureka M. & M. Co.
Cisco	Enterprise	1865	..	..	Steam.	30,000	..do ...	
Eureka Township	Birchville	1868	10	..	..do ...	15,000	..do ...	
Eureka Township	Black & Young's	1866	10	..	..do ...	15,000	..do ...	John Young, sup't.
Eureka Township	Grizzly M. Co	1866	10	..	..do ...	10,000	..do ...	Myron Foot, sup't.
Eureka Township	Mutual	1867	10	..	..do ...	15,000	..do ...	Thomas Loyd.
Eureka Township	Poquillon	1867	10	..	Water.	10,000	..do ...	
French Corral	American M. Co	1865	..	..	..do ...	7,000	..do ...	American Mining Co.
French Corral	American M. Co‡	1866	4	..	..do ...	3,000	..do ...	Do.
French Corral	Empire‡	1865	10	..	..do ...	7,000	..do ...	Do.
Grass Valley	Allison Ranch	1856	12	..	Steam.	30,000	..do ...	A. E. Davis, sup't.
Grass Valley	Alta Hill	1862	8	..	..do ...	22,000	..do ...	
Grass Valley	Ben. Franklin§	1869	..	..	....	....	..do ...	Campbell, Stoddard & Co.
Grass Valley	Byers's	1865	4	..	Water.	....	..do ...	
Grass Valley	Cambridge	1866	10	..	Steam.	30,000	..do ...	
Grass Valley	Coe Gold M. Co	1867	10	..	..do ...	20,000	..do ...	Paul & Bever.
Grass Valley	Empire G. M. Co	1866	30	..	..do ...	125,000	..do ...	J. F. Nesmith, sup't.
Grass Valley	Eureka G. M. Co	1864	30	..	..do ...	30,000	..do ...	William Watt, sup't.
Grass Valley	Eureka No. 2	1870	..	..	..do ...	5,000	..do ...	Silvester & Co.
Grass Valley	Forest Springs	1857	4	..	Water.	....	..do ...	
Grass Valley	Gold Hill	1853	20	..	Steam.	20,000	..do ...	
Grass Valley	Harteree	1866	8	..	..do ...	20,000	..do ...	
Grass Valley	Iono M. Co	1865	10	..	..do ...	10,000	..do ...	
Grass Valley	Lady Franklin	1856	8	..	..do ...	10,000	..do ...	
Grass Valley	Laramie	....	8	..	Water.	8,000	..do ...	Frank Morse.
Grass Valley	Laton's	1864	8	..	Steam.	8,000	..do ...	B. B. Laton.
Grass Valley	Metallurgical Works	1862	..	..	..do ...	3,000	..do ...	William Hill.
Grass Valley	Metallurgical Works	1865	..	..	..do ...	3,000	..do ...	Days & Clark.
Grass Valley	Metallurgical Works	1865	..	..	..do ...	6,000	..do ...	Eureka Mining Co.
Grass Valley	Metallurgical Works	1867	..	..	..do ...	3,000	..do ...	Eli Burr.

* According to the census A. C. Mack's mill, with five stamps and one arrastra, (silver,) and H. W. Walker's, with two arrastras, (gold,) are also in this county; in the same report Williams's is a five-stamp mill.

† In the above list the mills of the Idaho Company, at Grass Valley, containing fifteen stamps, and that of the Greenhorn Company, eight stamps, appear to be omitted. They may, however, be recorded under different names.

‡ Cement mills. § Not completed.

List of quartz mills, &c.—Continued.

CALIFORNIA—Continued.

Location.	Name of mill.	When erected.	No. of stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
NEVADA CO.—Cont'd.								
Grass Valley	North Star	1854	16	..	Steam.	$40,000	Gold ..	Dudley Hoyt, sup't.
Grass Valley	Pacific Ore Co	1866	5	..	..do ...	10,000	..do ...	
Grass Valley	Rocky Bar	1854	16	2	..do ...	30,000	..do ...	
Grass Valley	Sebastopol	1863	12	4	..do ...	20,000	..do ...	
Grass Valley	Town Talk	1864	8	..	..do ...	10,000	..do ...	
Grass Valley	Union Hill	1866	20	..	..do ...	20,000	..do ...	Charles Bever, sup't.
Grass Valley	William Penn*	1869	..	..			..do ...	William Penn G. M. Co.
Grass Valley	Wolf Creek	1863	5	..	Water.	6,000	..do ...	Joseph Perrin.
Grass Valley	Woodworth & Co's	1865	15	..	Steam.	30,000	..do ...	
Hunt's Hill	Carney & Co's†	1866	8	..	Water.	5,000	..do ...	Carney & Co.
Hunt's Hill	Clay & Co's†	1866	8	..	..do ...	5,000	..do ...	
Hunt's Hill	Eastern†	1866	8	..	..do ...	3,000	..do ...	
Hunt's Hill	Empire†	1866	10	..	..do ...	4,000	..do ...	
Hunt's Hill	Gouge Eye†	1866	8	..	..do ...	3,000	..do ...	
Hunt's Hill	Green Mountain†	1866	10	..	..do ...	7,000	..do ...	
Hunt's Hill	Jenny Lind†	1866	8	..	..do ...	3,000	..do ...	
Little York	Curran & Buckman's†	1864	8	..	..do ...	8,000	..do ...	Curran & Buckman.
Little York	Remington & Pond's†	1865	10	..	..do ...	9,000	..do ...	Remington & Pond.
Meadow Lake	Cal. Con. M. & M. Co	1865	8	..	Steam.	17,000	..do ...	
Meadow Lake	Excelsior M. & M. Co	1866	20	..	..do ...	75,000	..do ...	
Meadow Lake	U.S.Grant M. & M.Co	1865	5	..	..do ...	15,000	..do ...	
Meadow Lake	Winton	1865	10	..	..do ...	22,000	..do ...	
Nevada Township	Banner	1866	40	..	..do ...	45,000	..do ...	W. L. Tisdale, sup't.
Nevada Township	Cal. G. M. Co.	1867	10	..	..do ...	30,000	..do ...	
Nevada Township	Cornish	1859	6	2	Water.	8,000	..do ...	Phil. Richards, sup't.
Nevada Township	Federal Loan	1865	2	..	Steam.	2,000	..do ...	Hicker & Co.
Nevada Township	Metallurgical Works	1860	..	..		5,000	..do ...	O. Maltman, sup't.
Nevada Township	Murchie's	1863	8	..	Water.	5,000	..do ...	John Murchie.
Nevada Township	Nevada Q. M. Co	1861	12	..	..do ...	25,000	..do ...	
Nevada Township	Oriental	1854	8	..	Steam.	10,000	..do ...	—— Kitts.
Nevada Township	Pennsylvania	1864	8	..	..do ...	9,000	..do ...	J. H. Helm.
Nevada Township	Pittsburg G. M. Co.	1868	10	..	..do ...	60,000	..do ...	C. P. Purington, sup't.
Nevada Township	Sneath & Clay's	1863	12	..	..do ...	65,000	..do ...	
Nevada Township	Stiles's	1861	8	..	Water.	5,000	..do ...	W. C. Stiles.
Red Dog	Wier & Garber's†	1861	6	..	..do ...	2,500	..do ...	
Red Dog	Williams & Riggs's†	1864	12	..	Steam.	15,000	..do ...	
Red Dog	Wright & Co's†	1865	10	..	Water.	5,000	..do ...	
Washington Twp	Brandy Flat M. Co†	1868	4	..	..do ...	2,500	..do ...	
Washington Twp	Fidelity Q. M. Co	1870	10	..	..do ...	8,000	..do ...	J. S. Holbrook, sup't.
Washington Twp	Marrietta M. Co	1868	10	..	..do ...	10,000	..do ...	Baxter, Lindsey & Co.
Washington Twp	Milton Willis M. Co†	1865	4	..	..do ...	3,000	..do ...	
Washington Twp	Star Q. M. Co	1863	10	..	Steam.	15,000	..do ...	A. Sanford, sup't.
Washington Twp	Tecumseh Q. M. Co.	1864	4	..	Water.	16,000	..do ...	Fidelity Mining Co.
Washington Twp	Van Dusen, Thomas & Co.	1869	5	..	..do ...	4,000	..do ...	Van Dusen & Thomas.
You Bet	Brown Brothers†	1864	8	..	..do ...	6,500	..do ...	H. K. Brown, sup't.
You Bet	Heydlauff's†	1865	10	..	..do ...	5,000	..do ...	—— Heydlauff, sup't.
You Bet	Mallory & Co's†	1866	8	..	..do ...	4,500	..do ...	
You Bet	Neece & West's†	1865	10	..	..do ...	6,000	..do ...	
You Bet	Union†	1865	10	..	..do ...	7,000	..do ...	
PLACER COUNTY.								
Auburn	Graves & Putnam	1870	10	..	Steam.	3,000	Gold ..	Graves & Puttnam.
Bald Hill	Golden Rule	1869	20	..	..do ...	20,000	..do ...	Green Emigrant Co.
Bath	Golden Gate Co†	1865	5	..	Water.	6,000	..do ...	Golden Gate Co.
Bath	Paragon†	1863	20	..	Steam	15,000	..do ...	J. Wheeler, agent.
Bath	Rough Gold Co†	1865	10	..	..do ...	12,000	..do ...	William Davis, agent.
Colfax	Live Oak	1862	5	..	Water.	4,000	..do ...	John McKinney, ag't.
Colfax	Rising Sun	1869	5	..	Steam.	6,000	..do ...	Rising Sun Co.
Damascus	Damascus C. M†	1867	10	..	Water.	8,000	..do ...	Robert Lewis & Co.
Damascus	Pioneer	1855	6	..	Steam.	12,000	..do ...	Colman & Co.
Devil's Cañon	Missouri Co†	1866	10	..	..do ...	12,000	..do ...	A. Moore & Co.
Doty's Flat	McFadden & Sears†	1870	10	..	Water.		..do ...	McFadden & Sears.
Dutch Flat	McCullough's	1866	5	..	Steam.	5,000	..do ...	McCullongh Min'g Co.
Empire City	Empire	1869	10	..	Water.	10,000	..do ...	—— McFadden.
Forest Hill	Baltimore†	1866	10	..	Steam.	7,000	..do ...	William Northwood.
Forest Hill	Big Spring Co†	1866	10	..	..do ...	10,000	..do ...	J. P. Castner & Co.
Forest Hill	Hope Co†	1866	20	..	..do ...	15,000	..do ...	George W. Reamer.
Forest Hill	Oro Co†	1866	20	..	..do ...	12,000	..do ...	Geo. W. Reamer, agent.
Gold Hill	Gold Hill	1868	6	..	Water.	4,000	..do ...	Steven Quinn & Co.

* Not completed. † Cement mills.

List of quartz mills, &c.—Continued.

CALIFORNIA—Continued.

Location.	Name of mill.	When erected.	No. of stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
PLACER CO.—Con.								
Gold Run	Indiana Hill*	1865	10	..	Water.	$8,000	Gold ..	A. H. Mallory, agent.
Harpending Mine	Banker	1865	5	..	Steam.	5,000	..do ...	Harpending Mill Co.
Harpending Mine	San Francisco Co.	1866	40	..	..do ...	....	..do ...	Do.
Iowa Hill	Morning Star*	1865	10	..	..do ...	10,000	..do ...	James Dods & Co.
Newcastle	Schnabel's	1865	5	..	Water.	2,000	..do ...	—— Schnabel.
Ophir	Pugh's	1863	5	..	..do ...	2,000	..do ...	C. D. Pugh & Co.
Ophir	Welty's	1865	10	..	Steam.	6,000	..do ...	Welty & Co.
Ophir	St. Lawrence	1867	10	..	Water.	8,000	..do ...	Staples & Co.
Secret Cañon	Secret Spring	1864	6	..	Steam.	10,000	..do ...	Grant & Co.
Stewart's Flat	Stewart's Flat	1864	5	..	..do ...	3,000	..do ...	J. Rogers.
Whiskey Diggings	....	1866	10	..	..do ...	6,000	..do ...	
Whiskey Diggings	Baker & Crosby's	1866	40	..	..do ...	50 000	..do ...	Peachy, Hoffman & Co.
Wisconsin Hill	Oriental	1866	20	..	..do ...	25,000	..do ...	Conklin, Hosmer & Co.
....	Arnold, Lee & Co.'s	1866	10	..	..do ...	....	..do ...	Arnold, Lee & Co.
PLUMAS COUNTY								
Argentina	Malloy & Co.'s	1870	5	..	Steam.	....	Gold ..	Malloy & Co.
Cherokee	Caledonia	1867	12	..	..do ...	25,000	..do ...	Lovel White.
Cherokee	Cherokee	1865	16	..	Water.	25,000	..do ...	Judkins & Kellogg.
Cherokee	New York	1867	12	..	..do ...	10,000	..do ...	L. G. Traugh.
Dixie	Batchelder's	1863	6	..	..do ...	5,000	..do ...	J. B. Batchelder.
Eureka Lake	Eureka	1852	30	3	S. & W.	100,000	..do ...	John Farrott.
Franklin Hill	Franklin Hill Co.	1860	6	..	Water.	2,000	..do ...	Franklin Hill Co.
Genessee Valley	Keystone	1862	..	3	..do ...	1,500	..do ...	J. N. Blood.
Greenville	Greenville	1862	6	..	..do ...	6,000	..do ...	H. E. Bidwell.
Greenville	Lone Star	1862	8	..	..do ...	7,000	..do ...	Bidwell & Aschim.
Indian Valley	Crescent	1866	32	..	Steam.	60,000	..do ...	M. B. Bransford.
Indian Valley	Indian Valley	1863	20	..	..do ...	20,000	..do ...	J. N. Blood & Co.
Indian Valley	Pennsylvania	1863	16	..	..do ...	20,000	..do ...	Blood & Co.
Indian Valley	Whitney M. Co	1866	24	..	..do ...	20,000	..do ...	Do.
Jamison Creek	Mammoth	1851	12	2	Water.	20,000	..do ...	Mammoth Mining Co.
Jamison Creek	'76 Co	1852	..	3	..do ...	3,000	..do ...	Elwell, Nave & Co.
Mohawk Valley	King & Co	1866	4	..	..do ...	2,000	..do ...	King & Co.
Round Valley	Golden Gate	1862	16	2	Steam.	20,000	..do ...	Judkins & Kellogg.
Rush Creek	Berg Mill	1863	8	..	..do ...	15,000	..do ...	L. White.
SAN BERNARDINO COUNTY.								
Holcomb Valley	Mellus's	1860	4	4	Steam.	20,000	Gold ..	Richard Garvey.
Mojave	Green Lode	.....	..	6	Water.	1,000	..do ...	George E. Moore.
SAN DIEGO COUNTY.								
Branson District	McPherson	1870	2	..	Steam.	6,000	Gold ..	
Julian District	McMechan's	1870	2	..	..do ...	4,000	..do ...	James McMechan.
Julian District	Parson	1870	10	..	..do ...	3,000	..do ...	Parson & Cotton.
SHASTA COUNTY.								
French Gulch	Highland	1863	10	..	Steam.	10,000	Gold ..	Thomas Purnell, sup't.
French Gulch	Honeycomb	1865	8	2	Water.	6,000	..do ...	S. Grover.
French Gulch	Washington	1851	10	..	..do ...	10,000	..do ...	J. Syme, sup't.
Lower Springs	George's	1866	..	..	Steam.	1,500	..do ...	W. H. George.
Old Diggings	Mammoth	1864	8	..	..do ...	20,000	..do ...	I. Isaacs.
SIERRA COUNTY.								
Alleghanytown	Eagle	1866	10	..	Steam.	12,000	Gold ..	Eagle Q. M. Co.
Alleghanytown	21 Q. M. Co	1865	4	..	Water.	4,500	..do ...	21 Q. M. Co.
American Hill	American Hill	1858	6	..	S. & W.	8,500	..do ...	Young & Co.
American Hill	Von Humboldt	1870	8	..	Water.	12,000	..do ...	Von Humboldt Co.
Chipps	Rainbow	1857	8	..	Steam.	8,500	..do ...	
Divide	Keystone Q. M. Co	1858	12	..	..do ...	12,500	..do ...	Keystone Q. M. Co.
Downieville	Gold Bluff	1858	12	1	Water.	14,100	..do ...	Stumpfy & Co.
Downieville	Leonard's	1869	4	..	..do ...	3,000	..do ...	Leonard & Co.
Downieville	Montpelier Co	1858	8	1	..do ...	7,000	..do ...	Montpelier Q. M. Co.
Downieville	Oro Co	1860	..	2	..do ...	6,000	..do ...	
Gold Lake	Haven & Co.'s	1860	8	..	..do ...	5,150	..do ...	Havens & Lemprich.
Hog Cañon	Primrose Co	1858	12	..	Steam.	15,400	..do ...	Primrose Mining Co.

* Cement mills.

List of quartz mills, &c.—Continued.

CALIFORNIA—Continued.

Location.	Name of mill.	When erected.	No. of stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
SIERRA CO.—Con.								
Jim Crow Cañon	Ironsides	1864	8	..	S. & W.	$10,000	Gold	Ironsides Q. M. Co.
Jim Crow Cañon	Plumbago	1862	..	1	Water	2,000	..do	Hoadley & Co.
Jim Crow Cañon	Sierra Consolidated	1863	12	..	Steam	60,000	..do	Sierra Con'd Q. M. Co.
Kanaka Creek	Oak Flat Co	1863	8	..	Water	7,000	..do	Oak Flat Q. M. Co.
Kanaka Ravine	Kanaka Q. M. Co	1865	20	..	..do	22,500	..do	Kanaka Q. M. Co.
Middle Yuba River	French	1865	5	..	..do	4,000	..do	French Co.
Minnesota	Briggs & Co.'s	1863	5	..	Steam	6,500	..do	Briggs & Co.
Minnesota	California	1855	4	..	Water	4,000	..do	Wright & Bowen.
Mountain House	Brush Creek	1868	10	..	Steam	20,000	..do	Brush Creek Co.
Mountain House	Mountain House	1858	4	..	..do	5,350	..do	Watson & Co.
Pike City	Alaska	1866	5	..	..do	7,000	..do	Alaska Co.
Sierra Buttes	Bigelow Co	1858	4	2	..do	6,000	..do	Bigelow & Moore.
Sierra Buttes	Independence	1858	36	2	Water	36,000	..do	Independence M. Co.
Sierra Buttes	Mexican	1858	..	2	..do	1,000	..do	Maldonado & Co.
Sierra Buttes	Sierra Buttes Co	1852	16	4	..do	30,000	..do	Sierra Buttes Co.
Sierra Buttes	....do	....	16	..	..do	30,000	..do	Do.
Sierra Buttes	....do	1870	40	..	..do	45,000	..do	Do.
Sierra City	Chipps	1867	8	..	..do	10,000	..do	Chipps Co.
Sierra City	Phœnix	1868	4	..	..do	5,000	..do	Beard & Co.
Wet Ravine	Union	1860	8	..	..do	8,600	..do	Union Q. M. Co.
Wolf Creek	Independence	1868	8	..	..do	8,000	..do	Independence Co.
Yuba River M. F	Four Hills	1862	4	..	..do	5,300	..do	Spencer & Grey.
Yuba River S. F	Chipps	1858	4	1	..do	4,200	..do	Manson & Co.
Yuba River S. F	Kentucky	1856	..	1	..do	5,000	..do	—— McKenzie.
SISKIYOU COUNTY.								
Cottonwood	Jones's	1870	4	..	Water	2,500	Gold	J. M. C. Jones.
Humbug Creek	Lash & Co.'s	1862	14	1	Steam	10,000	..do	Lash & Co.
Indian Creek	Siskiyou	1859	8	..	.do	8,000	..do	
Oro Fino	Shepard's	1870	8	..	Water	4,500	..do	H. T. Shepard.
Quartz Valley	Turk's	1857	4	1	..do	5,000	..do	F. Turk.
TRINITY COUNTY.								
East Fork	East Fork	1868	..	1	Water	600	Gold	H. Engle.
TULARE COUNTY.								
White River	Carter's	1866	10	..	Steam	20,000	Gold	J. Carter.
White River	White River	1861	8	..	..do	6,000	..do	J. C. Birdseye.
TUOLUMNE COUNTY.*								
American Camp	Star	1864	10	1	S. & W.	10,000	Gold	P. B. Bacon.
Bald Mountain	Sophia	1865	5	..	Water	5,000	..do	Phelps & Co.
Blue Gulch	Eagle	1865	10	..	..do	10,000	..do	Eagle M. Co.
Cherokee	Larco	1858	10	2	..do	3,000	..do	C. Lombardo.
Cherokee	Magee	1859	8	..	Steam	7,000	..do	Platt Bros.
Confidence District	Confidence	1869	30	3	..do	40,000	..do	Holladay & Co.
Deer Creek	Deer Creek	1865	5	..	..do	8,000	..do	Deer Creek Co.
Five-mile Creek	Hazel Dell	1864	5	..	Water	4,000	..do	Bacon, Wing & Co.
Five-mile Creek	Ryerson's	1865	..	..	Steam	10,000	..do	M. Brum gim.
Jackass Hill	Walter's	1859	5	..	Water	5,000	..do	Walters & Co.
N. F. Tuolumne River	Big Cañon	1858	10	..	..do	15,000	..do	Cobb & Sintin.
N. F. Tuolumne River	Bonita	1866	10	..	..do	10,000	..do	Bonita Co.
N. F. Tuolumne River	Consuelo	1866	20	..	..do	20,000	..do	Consuelo Co.
N. F. Tuolumne River	Grizzly	1859	20	..	..do	20,000	..do	Gashwiler & Co.
N. F. Tuolumne River	Starr King	1866	5	..	Steam	7,000	..do	R. Inch & Co.
Poverty Hill	Golden Rule	1865	20	..	..do	15,000	..do	Golden Rule Co.
Poverty Hill	Heslep's	1860	10	..	..do	10,000	..do	Heslep & Co.
Quartz Mountain	Knox & Boyle	1868	10	..	..do	8,000	..do	J. Hall.
Rawhide Ranch	Rawhide Ranch	1866	20	..	..do	45,000	..do	R. P. Johnson, agent.
Sonora	Sonora	1866	15	..	Water	15,000	..do	Sonora Gold Co.
Soulsbyville	Gilson's	1859	10	..	Steam	8,000	..do	Raymond & Gorham.
Soulsbyville	Soulsby	1858	20	..	..do	20,000	..do	D. Davidson & Co.
Stanislaus River	Telegraph	1860	20	..	Water	20,000	..do	Do.
Sugar Pine	Daegner	1864	10	..	Steam	10,000	..do	William Daegner.
Sugar Pine	Eureka	1859	20	..	Water	20,000	..do	—— Edwards, agent.
Sugar Pine	Excelsior	1860	10	1	..do	10,000	..do	J. & G. Wright.
Sugar Pine	Green's	....	5	..	Steam	....	..do	—— Green.

* According to the census report the Golden Rule Mill contains fifteen, and the App Mill ten stamps.

List of quartz mills, &c.—Continued.

CALIFORNIA—Continued.

Location.	Name of mill.	When erected.	No. of stamps.	No. of arastras.	Power.	Cost.	Gold or silver.	Present occupants.
TUOLUMNE Co.—Con.								
Sugar Pine	Lombardo	1860	8	..	Water.	$10,000	Gold ..	C. Lombardo.
Sugar Pine	Monitor	1863	5	4	..do ...	10,000	..do ...	Monitor G. & S. M. Co.
Sugar Pine	Pirate	1860	8	..	..do ...	10,000	..do ...	C. Dorsey.
Summerville	Summers's	1860	8	..	..do ...	8,000	..do ...	G. Summers.
Tuolumne River	Buchanan	1859	10	..	..do ...	10,000	..do ...	Tuolumne G. M. Co.
Turnback Creek	Laurel Hill	1857	10	2	..do ...	3,000	..do ...	San Francisco Co.
Tuttletown	Patterson's	1857	10	..	..do ...	10,000	..do ...	W. Patterson.
Whisky Hill	Preston's	1860	10	..	..do ...	4,500	..do ...	Rosencrans & Co.
Whisky Hill	Reist's	1860	5	..	..do ...	2,000	..do ...	C. Reist.
Whitman's Pass	Whitman's	1866	5	..	..do ...	5,000	..do ...	Milner & Co.
Wood's Crossing	App's	1860	20	..	S. & W.	15,000	..do ...	Totten & Griffing.
Wood's Crossing	Clem & Co.'s	1859	9	..	Water.	8,000	..do ...	Clem & Co.
Wood's Crossing	Duncan's	1859	4	..	..do ...	3,000	..do ...	J. Duncan.
Yankee Hill	Shanghai	1862	10	..	..do ...	10,000	..do ...	Gashwiler & Hooper.
YUBA COUNTY.								
Brown's Valley	Danebroge	1859	8	..	....	20,000	Gold ..	Danebroge M. Co.
Brown's Valley	Jefferson	1862	12	..	....	40,000	..do ...	Jefferson Mining Co.
Brown's Valley	Pennsylvania	1862	16	..	....	40,000	..do ...	Pennsylvania M. Co.
Brown's Valley	Sweet Vengeance	1865	20	..	....	50,000	..do ...	Sweet Veng'ce M. Co.
Eagleville	....	1865	8	..	....	15,000	..do ...	Incorporated.
Indian Ranch	Temple, No. 2	1866	8	..	....	30,000	..do ...	Do.
Middle Yuba	Mount Hope	1865	4	..	....	10,000	..do ...	Mount Hope M. Co.
Smartsville	Andrew Jackson	1866	10	..	....	12,000	..do ...	And'w Jackson M. Co.

NEVADA.

Location.	Name of mill.	When erected.	No. of stamps.	No. of arastras.	Power.	Cost.	Gold or silver.	Present occupants.
CHURCHILL COUNTY.								
Sink of Humboldt	Utica	1866	10	3	Water.	$75,000	Gold ..	
ELKO COUNTY.								
Cope District	Canty's	1870	2	..	Steam.	10,000	Silver.	Canty & Co.
Cope District	Drew	1869	10	..	..do ...	30,000	..do ...	Drew & Co.
Mineral Hill	Mineral Hill	1870	10	..	....	20,000	..do ...	
ESMERALDA COUNTY.*								
Aurora	Antelope	1864	20	..	Steam.	125,000	Silver.	Bank of California.
Aurora	Coffee	1864	8	..	..do ...	5,000	..do ...	J. J. Poor.
Aurora	Independence	1863	16	..	..do ...	60,000	..do ...	William Sharon.
Aurora	Napa	1862	8	..	..do ...	12,000	..do ...	Philadelphia Co.
Aurora	Old Antelope	1862	8	..	..do ...	40,000	..do ...	Bank of California.
Aurora	Real del Monte	1863	30	..	..do ...	225,000	..do ...	Bank of California.
Aurora	Stark & Tucker's	1863	10	..	..do ...	70,000	..do ...	Bank of California.
Aurora	Union	1862	8	..	..do ...	10,000	..do ...	J. J. Poor.
Aurora	Wide West	1862	20	..	..do ...	75,000	..do ...	Greely Bros.
Columbus	Eaton & Johnson's	1870	2	..	..do ...	10,000	..do ...	Eaton & Johnson.
Columbus	Pioneer	1870	10	..	..do ...	12,000	..do ...	Col. Youngs.
Palmetto	N. Y. and S. P. Co.'s	1867	10	..	..do ...	50,000	..do ...	N. Y. & Silver Peak Co.
Pine Grove	Central	1868	5	..	..do ...	10,000	Gold ..	H. C. Toombs.
Pine Grove	Pioneer	1866	10	..	..do ...	20,000	..do ...	McAdams Co.
Pine Grove	Wilson's	1867	10	..	..do ...	20,000	..do ...	William Wilson.
Red Mountain	Silver Peak and R. M	1868	40	..	..do ...	100,000	..do ...	S.P.&R.M.G.&S.M.Co
Rockland	Kean's	1870	10	..	..do ...	20,000	..do ...	S. Kean.
HUMBOLDT COUNTY.†								
Battle Mountain	Little Giant	1867	5	..	Steam.	12,000	Silver.	G. W. Fox.
Dun Glen	Essex	1867	10	..	..do ..	20,000	..do ...	Essex Co.
Golconda	Golconda	1867	10	..	S.& W.	20,000	..do ...	Star City Co.
Gold Run	Webb's	1869	10	..	Steam.	15,000	..do ...	L. D. Webb.

* The census reports for H. C. Toombs's mill 16, for the Pioneer 8, Wilson's 12, the Wide West 16, Red Mountain and Silver Peak 16, and Col. Young's Pioneer 12 stamps. Johnson's mill, 16 stamps, reported by the census, I cannot identify in the above list.

† According to the census, the Star City Company's mill has 8 stamps, L. D. Webb's 4 stamps, and the Pioneer mill 5 stamps.

List of quartz mills, &c.—Continued.

NEVADA—Continued.

Location.	Name of mill.	When erected.	No. stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
HUMBOLDT CO.—Con.								
Oreana	Oreana*	....	15	..	Steam	$50,000	Silver	Oreana Co.
Unionville	National	1862	4	..	..do	2,000	Gold	Evans & Jennings.
Unionville	Fall & Temple's	1867	10	..	..do	40,000	Silver	Fall & Temple.
Unionville	Pioneer	1862	10	..	S.& W.	35,000	..do	Pioneer Co.
Unionville	Silver Mining Co.	1862	5	..	Steam	12,000	..do	Silver Mining Co.
Winnemucca	Sphioda	1867	10	..	Water	10,000	..do	Sphioda Co.
LANDER COUNTY.								
Austin	Boston and Nevada	1865	10	..	Steam	80,000	Silver	
Austin	Manhattan	1865	20	..	..do	100,000	..do	Manhattan S. M. Co.
Cortez	Cortez	1864	13	..	..do	90,000	..do	Wenban & Page.
New York Cañon	Mettacom	1866	20	..	..do	50,000	..do	
Telegraph Cañon	Midas	1865	15	..	..do	120,000	..do	
Yankee Blade	Empire	1866	10	..	..do	60,000	..do	
LINCOLN COUNTY.								
Crescent City	Alameda	1868	10	..	Steam	80,000	Silver	
Dry Valley	Meadow V. M. Co.'s	1870	20	..	..do	100,000	..do	Meadow Valley M. Co.
El Dorado Cañon	El Dorado	1867	10	..	..do	60,000	..do	Riverside Mining Co.
Hiko	Hiko S. M. Co.'s	1866	10	..	..do	100,000	..do	I. Wilson, sup't.
Meadow Valley	Mee's	1870	10	..	..do	75,000	..do	James Mee.
Meadow Valley	Pioneer	1869	5	..	..do	40,000	..do	Ely & Raymond.
LYON COUNTY.								
Carson River	Carson Valley	1870	..	..	....	30,000	Silver	Carson Valley M. Co.
Carson River	Eureka	1861	20	..	Water	65,000	..do	Union M. & M. Co.
Carson River	Franklin	1861	10	..	S.& W.	35,000	..do	Union M. & M. Co.
Carson River	Island	1862	10	..	..do	35,000	Gold	Cook & Co.
Carson River	San Francisco	1861	10	..	..do	35,000	..do	C. A. Shad.
Carson River	Winters & Robedee's	1870	2	4	Water	5,000	..do	Winters & Robedee.
Carson River	Woodworth	1864	24	..	S.& W.	75,000	Silver	Hobart & Co.
Dayton	Birdsall & Co.'s†	1865	40	..	Water	145,000	..do	Birdsale & Co.
Dayton	Dancey	1863	75	..	Steam	55,000	..do	Dancey Mining Co.
Dayton	Illinois	1864	15	..	..do	35,000	..do	Union M. and M. Co.
Dayton	Imperial No. 2	1862	15	..	Water	40,000	..do	A. M. Edgington.
Dayton	Rock Point	1861	56	..	S.& W.	170,000	..do	A. M. Edgington.
Dayton	Tailings	1864	..	..	Steam	15,000	..do	Janin & Boyd.
Gold Cañon	Atlanta	1865	10	..	..do	8,000	G. & S	Hill & Co.
Gold Cañon	Eastern Slope	1862	16	..	..do	40,000	Silver	Rigby & Douglas.
Gold Cañon	Excelsior	1861	10	..	..do	25,000	G. & S.	Briggs & Co.
Gold Cañon	Kelsey No. 2	1866	..	2	..do	4,000	Silver	Hill & Co.
Gold Cañon	Keystone	1865	5	..	..do	10,000	G. & S	Likens & Co.
Gold Cañon	Phœnix	1862	20	..	..do	40,000	Silver	Hentsch & Berton.
Gold Cañon	Sacramento	1861	15	..	..do	35,000	..do	Union M. & M. Co.
Gold Cañon	Swansea	1862	20	..	..do	45,000	..do	Union M. & M. Co.
Gold Cañon	Weston's‡	1862	15	..	..do	35,000	..do	Weston & Co.
Silver City	Bacon	1863	20	..	..do	50,000	..do	Fair M. & Flood.
Silver City	Devil's Gate	1861	15	..	..do	25,000	..do	Devil's Gate M. Co.
Silver City	Eagle	1863	..	4	Water	5,000	Gold	Virginia Water Co.
Silver City	Hope	1870	10	..	Steam	30,000	..do	Hope Mining Co.
Silver City	Kelsey No. 1	1861	10	..	..do	25,000	Silver	Union M. & M. Co.
Silvor City	Pioneer	1861	15	..	..do	45,000	..do	J. P. Jones & Co.
Silver City	Sherman's	1870	5	..	..do	8,000	Gold	George Sherman.
Silver City	Trench's	1861	20	..	..do	50,000	Silver	Fair M. & Flood.
NYE COUNTY.§								
Belmont	Belmont S. M. Co.'s	1866	10	..	Steam	50,000	Silver	R. B. Canfield.
Belmont	Combination Co.'s	1868	40	..	..do	250,000	..do	

*Mill and furnace.

†Rebuilt in 1870.

‡Weston's mill is reported in the census with 20 stamps. The same source gives the aggregate number of stamps of the Union Milling and Mining Company as 146, while in the above list only 90 are enumerated. Birdsale & Co.'s mill, as far as I am informed, has no stamps. but 40 pans working tailings.

§According to the census report the mill of the Rigby Company has 5 stamps. The same report has the following mills, which I cannot identify in the above list: Cambridge Company, 20 stamps; Mammoth Company, 10 stamps; Utica & Herkimer, 5 stamps; Northumberland, 10 stamps; and Old Dominion, 10 stamps.

List of quartz mills, &c.—Continued.

NEVADA—Continued.

Location.	Name of mill.	When erected.	No. stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
NYE COUNTY—Con.								
Belmont	Gould & Curry	1868	3		Water.	$2,000	Silver.	John Miller.
Ellsworth	Pah Ute		3		Steam.		G. & S.	
Ellsworth	Jones's*		20		..do	4,000	..do	——— Jones.
Hot Creek	Hot Creek S. M. Co.	1867	10		..do	75,000	Silver.	Talman & Groves.
Hot Creek	Valley	1869	3		..do	6,000	..do	
Ione	Knickerbocker	1866	20		..do	100,000	..do	
Ione	Pioneer*	1865	10		..do	40,000	..do	
Northumberland	Quintero S. M. Co.'s	1868	10		..do	45,000	..do	
Ophir Cañon	Twin River S. M. Co's	1866	20		..do	180,000	..do	
Reveille	Rutland*	1867	5		..do	10,000	..do	
Reveille	S. F. & R. S. M. Co.*	1869	10		..do	30,000	..do	San Fran. & R. Co.
San Antone	Rigby S. M. Co		4		..do	12,000	..do	
Silver Park	Chandler & Parsons	1870	10		Steam.	†20,000	Silver.	Chandler & Parsons.
Silver Park	Silver Peak	1870	12		..do	†20,000	..do	Silver Peak M. & M. Co.
Washington			10		..do	†40,000	..do.	
ORMSBY COUNTY.								
Carson City	Brunswick‡	1864	16		Water.	50,000	Silver.	Union Mill. & M. Co.
Carson City	Merrimac	1861	20		..do	130,000	..do	Do.
Carson City	Santiago	1861	24		..do		..do	Do.
Carson City	Vivian	1861	16		..do	45,000	..do	Vivian M. Co.
Empire City	Mexican§	1861	44		..do	100,000	..do	Union Mill. & M. Co.
Empire City	Yellow Jacket	1865	40		S. & W.	200,000	..do	Yellow Jacket S. M. Co.
STOREY COUNTY.§								
American City	Badger ‖						Silver.	
American City	Bay State		23		Steam.	40,000	..do	
Gold Hill	Atlas	1864	15		..do	55,000	..do	Scale & Beatty.
Gold Hill	Boston	1867	5		..do	8,000	G. & S.	Smith & Stephenson.
Gold Hill	Douglass	1861	10		..do	15,000	Silver.	C. C Stevenson.
Gold Hill	Empire		20		..do		..do	Empire Mill Co.
Gold Hill	Gold Hill	1865	6		..do	18,000	..do	Gold Hill M. & M. Co.
Gold Hill	Imperial	1860	44		..do	100,000	..do	Imperial M. & M. Co.
Gold Hill	Ione		5		..do	9,000	..do	Hope M. & M. Co.
Gold Hill	Marysville		9		..do	50,000	..do	John Rule.
Gold Hill	Pacific		30		..do	120,000	..do	Pacific Mill Co.
Gold Hill	Papoose	1867	6		..do	14,000	..do	Taylor, Goulding & Armstrong.
Gold Hill	Petaluma	1867	24		..do	40,000	..do	Sharon & Mackey.
Gold Hill	Piute		20		..do	60,000	..do	W. S. Hobart.
Gold Hill	Ramsdell & Thomson's.	1866	4		..do	5,000	..do	Ramsdell & Thompson.
Gold Hill	Rhode Island		25		..do	100,000	..do	Belcher M. Co.
Gold Hill	Sapphire	1862	16		..do	30,000	..do	W. S. Hobart.
Gold Hill	Succor	1862	20		..do	20,000	..do	Succor M. & M. Co.
Gold Hill	Sunderland		10		..do	25,000	..do	Union M. & M. Co.
Gold Hill		1865	2		Water.	1,000	..do	Richard Schweiss.
Virginia City	Atlantic	1863	16		Steam.		..do	Union M. & M. Co.
Virginia City	Hoosier State	1862	18		..do	40,000	G. & S.	M. Lynch.
Virginia City	Land's		20		..do	60,000	Silver	Union M. & M. Co.
Virginia City	Mariposa		12		..do	20,000	..do	Fair & Mackey.
Virginia City	Sacramento & Meredith.	1870	20		..do	12,000	..do	Sacramento M. & M. Co.
Virginia City	Sierra Nevada	1868	20		..do		Gold.	
Virginia City	Summit	1864	20		..do	40,000	..do	N. H. A. Mason.
Virginia City	Winfield		18		..do	80,000	Silver.	Union M. & M. Co.
Virginia City			5		..do		..do	Berry, Evans & Co.

* Rebuilt in 1870.
† Estimated cost.
‡ The number of stamps of the Brunswick mill is given by the census as 20.
§ Remodeled 1870.
‖ It is impossible to reconcile the list with that furnished by the census. According to the latter the following mills are here omitted: Proctor, Jennings, Bassett's, Parks & Bowie's, Evan's—all tailing mills; and Gould & Curry, 80 stamps; Ogden, 15; Flowery, 18; Nevada, 21; Bassett's, 18; Empire State, 15; Occidental, 30 stamps. According to the same source the Succor has 15; the Empire, 16; the Hoosier State, 15; the Atlas, 18; Bay State, 18 stamps. On the other hand several mills which appear in the above list are not contained in the census, or cannot be identified.

List of quartz mills, &c.—Continued.

NEVADA—Continued.

Location.	Name of mill.	When erected.	No. stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
WASHOE COUNTY.								
Franktown	Dall's	1862	60	..	S. & W.	$250,000	Silver	John Dall.
Pleasant Valley	Temelic	1862	15	..	..do ...	75,000	..do ...	Union M. & M. Co.
Truckee Meadows	English Company's	1862	20	..	Water.	200,000	..do ...	J. J. Dunne.
Washoe City	Atchison	1861	20	..	S. & W.	80,000	..do ...	Savage M. & M. Co.
Washoe City	Back Action	1866	..	8	Steam.	10,000	..do ...	D. E. Avery.
Washoe City	Little Savage	1868	..	8	..do ...	10,000	..do ...	Do.
Washoe City	New York	1865	24	.	..do ...	110,000	..do ...	Union M. & M. Co.
Washoe City	Savage	1863	16	..	S. & W.	75,000	..do ...	Savage M. & M. Co.
WHITE PINE COUNTY.								
Eberhardt	Stanford's	1869	30	..	Steam.	250,000	....	Aurora South Co.
Egan	Social & Steptoe's	1867	10	..	..do ...	25,000	....	Social & Steptoe Co.
Egan	Social & Steptoe's Old Mill.	....	5	..	..do ...	....	....	Do.
Hamilton	Big Smoky	1869	20	..	..do ...	60,000	Silver.	Treasure Hill M. & M. Co.
Hamilton	Chicago	1869	10	..	..do ...	30,000	..do ...	Chicago Co.
Hamilton	Dayton	1869	20	..	..do ...	100,000	..do ...	H. G. Blasdell.
Hamilton	Henderson's	1869	5	..	..do ...	15,000	..do.	
Hamilton	Manhattan	1869	[illegible]	.	..do ...	120,000	..do ..	H. G. Blasdell.
Hamilton	Nevada	1869	[illegible]	..	..do ...	35,000	..do ...	McCone & Dunn.
Hamilton	Swansea	1869	10	..	..do ...	30,000	G. & S.	Perkins, Flint & Co.
Hamilton	Treasure	1869	5	..	..do ...	40,000	Silver.	Great Basin Co.
Hamilton	White Pine	1869	10	..	..do ...	30,000	..do ...	Miller & Co.
Mineral City	Robinson's	....	10	..	..do ...	....	....	Mineral City Co.
Monte Christo	Monte Christo	1865	5	..	..do ...	15,000	....	Monte Christo Co.
Newark	Newark	1866	20	..	..do ...	60,000	....	Chihuahua Co.
Shermantown	Drake's	1869	10	..	..do ...	40,000	Silver	Eberhardt Co.
Shermantown	Kohler's	1868	5	..	..do ...	15,000	..do ...	
Shermantown	Little Giant	1869	5	..	..do ...	24,000	..do ...	Carpenter & Brett.
Shermantown	Metropolitan	1869	15	..	..do ...	120,000	..do ...	Metropolitan Co.
Shermantown	Oasis	1868	8	..	..do ...	70,000	..do ...	Eberhardt Co.
Shermantown	Sheba	1869	10	..	..do ...	45,000	..do ...	Osborn & Corey.
Shermantown	Staples	1869	8	..	....	45,000	....	Butler & Sweeney.
Shermantown	Vernon	1869	8	..	....	25,000	....	Vernon Mill Co.

OREGON.

Location.	Name of mill.	When erected.	No. stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
BAKER COUNTY.								
Auburn	White & Company's	....	..	1	....	....	Gold..	E. M. White & Co.
Baker City	Ruckels's*	1864	10	..	Water.	$6,000	..do ...	Brown & Virtue.
Rye Valley	Green's	1870	..	1	....	....	Silver.	Charles Green.
GRANT COUNTY.								
Prairie Diggings†	Prairie Diggings	1868	8	1	Water.	20,000	Gold..	Lacock & Co.
JACKSON COUNTY.‡								
Applegate	Steamboat	1860	4	3	Water.	8,000	Gold..	Fowler & Co.
Dardanelles	Occidental	1866	10	2	Steam.	1,200	..do ...	Hogan & Co.
Jackson Creek	Hopkins's	1860	5	1	..do ...	8,000	..do ...	Hopkins & Co.
Jackson Creek	Johnson's	1862	..	2	Water.	4,000	..do ...	Johnson & Co.
Rogue River	Jewett's	1861	5	..	Steam.	10,000	..do ...	Byba & Co.
Sterling	Ives's	1865	..	1	Horse.	500	..do ...	Porter Ives.
Thompson Creek	Thompson Creek	1865	..	4	Water.	1,500	..do ...	Morris & Co.

* The census reports Ruckels's mill to have 12 stamps, and unless the number of stamps has been decreased since 1869, when I visited the locality, this is the correct number.

† According to the census the Prairie Diggings mill has now 10 stamps; the same authority mentions another mill in this county, which must have been erected during 1870, viz, that of the John Day Company, 8 stamps.

‡ When I visited the county in 1869, Hopkins's and Jewett's mills were both altered into saw-mills. (See last report, page 216.)

List of quartz mills, &c.—Continued.

OREGON—Continued.

Location.	Name of mill.	When erected.	No. stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
JOSEPHINE COUNTY.								
Enterprise	Enterprise	1865	10	2	Water.	$18,000	Gold	—— Cohen.
UNION COUNTY.								
Eagle Creek	Eagle	....	..	..	....	....	....	Meacham Bros. & Co.
Hoquim	Carter & Davis	1865	5	1	Water.	8,000	Gold	Carter & Davis.
Kooster	La Grande	1866	5	..	..do ...	8,000	....	La Grande Co.

IDAHO.

Location.	Name of mill.	When erected.	No. stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
ALTURAS COUNTY.								
Bear Creek	Idaho	1865	12	..	Steam.	....	G. & S.	Idaho M. Co.
Bear Creek	Waddingham G. and S. M. Co.	....	10	..	..do ...	....	..do ...	Waddingham G. and S. M. Co.
Clifden	Waddingham G. and S. M. Co.	....	40	..	Steam.	....	..do ...	Do.
Elk Creek	Pittsburg & Idaho G. and S. M. Co.	....	10	3	....	....	..do ...	P. and I. G. and S. M. Co.
Red Warrior Creek	Harris & Benson	....	10	..	....	....	..do ...	Harris & Benson.
Red Warrior Creek	N. Y. & Idaho G. M. Co.	....	10	..	Steam.	....	..do ...	N. Y. & Idaho G. M. Co.
Red Warrior Creek	Victor G. and S. M. Co.*	....	20	..	..do ...	....	..do ...	Victor G. and S. M. Co.
Volcano	Defrees	....	10	..	....	....	..do ...	
Yuba District†	Bledsoe	....	10	..	....	....	..do ...	
BOISÉ COUNTY.								
Granite Creek	Gold Hill	1867	25	..	Steam.	$75,000	Gold	Gold Hill Company.
Granite Creek	White & Co.'s	1870	10	..	..do ...	15,000	..do ...	White & Co.
Grimes Creek	Goodwin	1865	8	..	Water.	....	..do ...	Goodwin & Co.
Pioneer	Elk Horn	1865	8	..	..do ..	....	..do ...	Elk Horn Mill Co.
Summit Flat	Summit Flat	1865	8	..	Steam.	....	..do ...	Goodwin & Co.
IDAHO COUNTY.								
Florence	Davis & Souther's	...	5	..	Steam.	....	Gold	Davis & Souther.
Warren's Diggins	....	....	5	..	..do ...	....	..do ..	
Warren's Diggins	....	....	10	..	Water.	....	..do ...	
LEMHI COUNTY.								
Arnett's Creek	Musgrove & Sons	1869	..	1	Water.	....	Gold	Musgrove & Son.
OWYHEE COUNTY.								
East Ruby	New York	1865	20	..	Steam.	140,000	G. & S.	Owyhee M. Co.
Flint District	Black's	1867	5	..	..do ...	20,000	..do ...	J. S. Black.
Flint District	Iowa	1867	..	..	..do ...	30,000	..do ...	John Williams.
Flint District	Rising Star	1868	30	..	..do ...	350,000	..do ...	Rising Star M. Co.
Silver City	Cosmos	1865	10	..	..do ...	70,000	..do ...	S. Williard.
Silver City	Ida Elmore	1865	20	..	..do ...	120,000	..do ...	Ida Ellmore M. Co.
Silver City	Minear	1864	5	..	..do ...	25,000	..do ...	Minear M. and M. Co.
Silver City	Morning Star	1864	8	..	..do ...	75,000	..do ...	Oro Fino G. and S. M. Co.
Silver City	Shoenbar	1865	10	..	..do ...	60,000	..do ...	O. S. Hazard.
Silver City	Webfoot	1865	5	..	..do ...	25,000	..do ...	Webfoot Milling Co.
Sinker Creek	Ainsworth	1864	10	..	..do ...	70,000	..do ...	Oregon S. N. Co.
Sinker Creek	Sinker Creek	1865	10	..	..do ...	70,000	..do ...	Sinker Milling Co.

* According to the statement of Mr. P. S. Buckminster, who visited this district for me in the latter part of 1869, the Victor mill had only 12 stamps and was standing idle.

† The Monarch mill, with one French burr, one cast-iron grinder, two Varney pans, one settler, and one roasting furnace, is omitted here.

List of quartz mills—Continued.

MONTANA.

Location.	Name of mill.	When erected.	No. of stamps.	No. of arrastras or pans.	Power.	Cost.	Weight of stamp.	Height of drop, inches.	Gold or silver.	Present owners.
DEER LODGE COUNTY.										
Cable City	Nowlan	1867	20	2	Steam	$48,000	472	7	Gold	Plaisted & Co.
Cable City	Hanauer	1868	20		do	25,000	490	9	do	Hanauer & Co.
Butte	Butte	1869	10	1	do		500	8	do	Ray & Co.
Philipsburg	James Stuart	1867	10	6	do	70,000	650		Silver	St. Louis & Montana Mining Company.
Georgetown	Hervey	1868	10		do	20,000			Gold	Wheeling Mining Company.
Georgetown	Ewing	1868	8		do	20,000			do	Pittsburg & Montana Mining Company.
Highland	Swallow	1868	24	2	do	35,000			do	Highland Gold Company.
LEWIS AND CLARK COUNTY.										
Unionville	Tatom	1867	30	2	do	45,000	650	7½	do	Columbia Mining Company.
Unionville	Hodge	1866	20		do	30,000			do	National Mining & Exploring Comp'ny.
Grizzly Gulch	Ricker	1865	24	2	do	30,000	600	10	do	J. C. Ricker.
Nelson Gulch	Gormley	1866	12	2	do	27,000	550	10	do	C. Hendrie.
Grizzly Gulch	Addis	1867	10	2	do	20,000	650	8	do	Diamond City Company.
Oro Fino	Hendrie	1869	20	2	do	18,000	550	9	do	C. Hendrie.
Oro Fino	Shafer	1867		1	Water	2,000			do	J. Shafer.
Grizzly Park	Turnley	1865	10	1	Steam	20,000	666	11½	do	S. Turnley.
Ten Mile	Allen	1868	10	2	do	25,000	650		do	Kaiser & Co.
Blue Cloud	Blue Cloud	1868	10	1	do	25,000	650	7½	do	Comer & Co.
Greenhorn	Burdeck	1868	10	1	do	20,000	500		do	Plymouth Mining Company.
Grizzly Gulch	Whitlatch	1870	12		do	25,000			do	J. W. Whitlatch.
JEFFERSON COUNTY.*										
Crow Creek	Ross	1870	8		do	6,000			do	Ross & Logan.
Naves	Nave	1869	6		Water	3,000			do	James Nave & Sons.
Radersburg	Blacker	1870	15	1	Steam	20,000			do	Blacker & Keating.
Radersburg	Sample	1870	12		do	15,000			do	George W. Sample.
MADISON COUNTY.										
Sterling	Midas	1867	5	5	do	85,000	860	7	do	Midas Mining Company.

Sterling	Pratt	1866	20	8	W. & S.	65,000	700	10	do	New York & Montana Mining Comp'ny.
Sterling	Hartford	1866	12	2	Steam	60,000	500	14	do	Clark & Upsom.
North District	Copo	1865	15	2	do	45,000	550	16	do	George Cope.
Hot Springs	Atkins	1866	12	......	do	18,000	450	12	do	C. Hendrie.
Hot Springs	McAndrew & Wann	1867	5	2	Water	15,000	700	12	do	Madison Mining Company.
Hot Springs	Hobart	1868	5	2	do	10,000	800	10	do	Appleton & Co.
Hot Springs	Hall & Spaulding	1868	10	2	do	20,000	750	8	do	Hall & Spaulding.
Rochester	Hendrie	1868	10	1	Steam	20,000	500	......	do	Watsaka Mining Company.
Rochester	Wann	1868	10	2	do	20,500	500	......	do	Madison Mining Company.
Quartz Hill	Quartz Hill	......	3	......	Water	......	400	12	do	A. W. Whitacker.
Mill Creek	Branham	1865	12	......	do	......	500	12	do	C. C. Branham.
Silver Star	Everett	1867	10	4	Steam	25,000	680	8½	do	Everett, Green Campbell Company.
Silver Star	Trivitt	1868	12	2	do	30,000	600	9	do	Stevens & Trivitt.
Summit	Howe	1866	20	2	do	......	......	......	do	Howe Mining Company.
Summit	Hawkins	1868	15	......	do	30,000	......	......	do	Postlewhaite, Ray & Co.
Summit	Philadelphia	......	Chilian Mill		do	......	......	......	do	Montana Gold and Silver Mining Co.
Summit	Lucas	1867	20	......	do	30,000	......	......	do	Lucas Mining Company.
Brown District	Conner	1868	10	......	do	15,000	......	......	do	Golden Gate Mining Company.
BEAVER HEAD COUNTY.										
Bannack	Dakota	1863	12	......	Water	20,000	......	......	do	
Bannack	Butterfield	1864	12	......	Steam	25,000	550	14	do	Butterfield & Hopkins.
Bannack	Eaton	1867	40	......	S. & W.	35,000	700	11	do	Montana Mineral Land & Mining Co.
Bannack	Hopkins	1869	5	......	Water	5,000	700	9	do	R. P. Hopkins.
Bannack	N. E. Wood	Bullock crusher and pans.				......	......	......	do	
MEAGHER COUNTY.										
Trout Creek	Vantilburgh	1867	5	......	Water	5,000	......	......	do	Brainard Brothers.

* The census mentions the following arrastras in this county: Conly & Company, 1; J. W. Anderson, 1; J. H. Johnson & Son, 1; Temple, Wood & Company, 1.

List of quartz mills—Continued.

ARIZONA.

Location.	Name of mill.	When erected.	No. stamps.	No. arrastras.	Power.	Cost.	Gold or silver.	Present occupants.
PIMA COUNTY.								
Apache Pass	Harris or Montana	....	10	..	Steam.	....	Gold..	Harris or Montana Co.
YAVAPAI COUNTY.*								
Big Bug District	Big Bug	....	10	..	Steam.	....	Gold..	Gray & Hitchcock.
Hassayampa District.	Noyes & Curtis's	....	10	..	..do ...	....	S. & G.	Noyes & Curtis.
Hassayampa District.	Sterling's	....	10	..	..do ...	....	Silver.	Sterling Company.
Walker District	Eureka	....	10	..	..do ...	....	Gold..	C. C. Bean.
Walker District	Thunderbolt	....	1	..	..do ...	....	..do ...	
Wickenburg	Vulture	1866	40	..	..do ...	....	..do ...	Vulture Mining Co.
Wickenburg	Wickenburg	1865	10	..	..do ...	....	..do ...	Hinton's Est. & Co.
Bradshaw District	Jackson's	1870	4	2	..do ...	....	..do ...	Jackson Brothers.
Goodwin District	Bowers'	....	4	4	Water.	....	..do ...	H. Bowers & Co.
YUMA COUNTY.								
Gila City	Jones'	....	10	..	Steam.	....	Gold..	Jones & Co.

There are probably one hundred arrastras in the Territory, some of which are propelled by water and others by horse-power. As water is sometimes short, and Indians occasionally steal the horses, arrastras of either class are often idle. Some are abandoned for fear of Indian assaults. Arrastras are now running in Walker, Martinez, Bradshaw, Turkey Creek, Hassayampa and some other districts.

In Mojave County there is one stamp-mill, that of the Morse Association, at Hardyville. It has ten stamps, driven by steam, and the necessary pans and settlers. It was erected to work the gold ores from the celebrated Moss ledge, but is now idle.

* The Big Bug mill has one arrastra and the Thunderbolt four.

List of quartz mills—Continued.

NEW MEXICO.

Locality.	Name of mill.	Metal	Horse-power.		No. stamps.	Arrastras.
			Steam.	Water.		
TAOS COUNTY.						
San Antonio	Arroyo Hondo Mining and Ditch Co	Gold	....	36	20	...
COLFAX COUNTY.						
Negro Gulch	Bartolemew's	Gold	Steam.	....	....	....
Ute Creek	Aztec	..do	12	....	15	...
SANTA FÉ COUNTY.						
Real de Dolores	New Mexico Mining Co's	Gold	60	....	40	....
Real del Tuerto	Candelaria	..do	20	....	10	....
GRANT COUNTY.						
Pinos Altos	Pinos Altos Mining Company's	....	18	....	15	....
Bear Creek	Ryesron	....	18	....	10	....
Bear Creek	Reynolds & Griggs, (Amberg)	....	18	....	6	....

List of quartz-mills—Continued.

COLORADO.

Locality.	Name of mill.	No. of engines.	Horse-power.	No. of stamps.	Stamps running.	Horse-power used.
GILPIN COUNTY.						
Central City District	Ruh's, water-mill			6		
	Bates, pan-mill	1	25			
	Montezuma	1	120			
	Gunnell	1	15	18		
	Lexington	1	25	24	24	25
	Bay State	1	40			
	Montana	1	35	30		
	McIntyre	1	25	24		
	Winnebago	1	35	20	20	35
	Tasher	1	12	12		
	Kimber	1	12	12		
	Gunnell Central	1	30	24		
	Mather's	1	8	6	6	8
	Kip & Buell's, and hoisting	1	70	12	12	35
	Wilson's	1	12	10		
	Rocky Mountain	1	70	40	20	25
	Narragansett	1	80	50		
	Harper's	1	10	10		10
	Chlorine works, crusher, &c	1	15			
Russell and Lake Districts	North Star mill	1	75	22	22	75
	Ayers'	1	12	12		
	Rochdale	1	75	10		
	Bradley's	1	40	22		
	Lewis & Co			15		
	Sowden			12		
	Missouri's Hill			10		
	Moses'	1	12	12		
	Granada	1	100	30		
	Reed's	1	12	15		
	Lincoln's	1	15	12		
	Keystone	1	60			
	Monitor	1	40			
	Great Western	1	40			
	Brastow's	1	50	20	20	50
	Cheney's	1	12	12	12	12
	Pewabic	1	40			40
Nevada District	Potter's	1	15	15	15	15
	Clayton's	1	30	37	37	30
	Beverly & Koonce's	1	12	12	12	12
	New Bedford	1	16	12	12	16
	Sullivan's			12		
	Stoner	1	10	12		
	Waterman's	1	70	32	32	60
	Philadelphia	1	100	25	25	100
	Whitcomb's	1	25	22	22	25
	First National	1	70	25	25	70
	American Flag	1	50	10		
	Ophir	1	35	24		
	Gilpin	1	24	18	18	24
	Old Boston	1	12	12	12	12
	Boston and Colorado	1	100			
	La Crosse	1	12	12	12	12
	Hardesty's	1	15	12	12	15
	Beverly's	1	12	8		
	Eureka, (Waterman's)	1	25	20	20	25
Gregory and Enterprise Districts.	University	1	15	15	15	15
	Holbrook	1	12	15	15	12
	Nesmith	1	15	20	20	15
	Bobtail, (Lake's)	1	20	20	20	20
	Salisbury's	1	80	20	20	80
	Consolidated Bobtail	1	20	20	20	15
	Fulleiton's	1	15	15	15	15
	L. C. Miley's	1	15	20	20	16
	L. Arrighi's, (water)			10	10	
	Sensenderfer's			20	20	
	Polar Star	1	30	32	32	30
	Borham & Mellor's	1	20	20	20	20
	Holman's, (water)			12		
	Fitzpatrick's	1	18	10	10	18
	Consolidated Gregory	2	140	50	25	70

List of quartz mills—Continued.

COLORADO—Continued.

Locality.	Name of mill.	No. of engines.	Horse-power.	No. of stamps.	Stamps running.	Horse-power used.
GILPIN COUNTY—Continued.						
Gregory and Enterprise Districts—Continued.	J. B. Norton's	1	20	24	24	20
	New York	1	45	55	55	45
	Sullivan & Wheeler's	1	15	21	......	......
	———	1	20	10	......	......
	Eagle G. M. Co	1	100	50	......	......
	Rollins G. M. Co	1	80	10	......	......
	Hetzer's	......	......	10	......	......
	Dickerson's	1	25	15	......	25
	Whipple	1	20	......	......	......
	Teats, (crushers, &c)	1	20	......	......	......
	Rough's	......	......	15	......	......
	Smith & Parmelee	2	85	25	25	60
	Briggs	1	125	50	......	......
	Douglas	1	60	20	......	......
	Sterling	1	15	20	......	......
	Walker's	1	20	12	12	12
	Shearer	1	10	8	......	......
	Manhattan	2	40	......	......	......
	Boston and Colorado	1	20	Furnaces.		20
	Chicago	1	20	20	......	......
	Hurd's	1	20	26	......	......
	S. B. Morgan, Agent	1	40	......	......	......
	Perigo Co	2	140	......	......	......
	Black Hawk G. M. Co	1	120	85	85	101

List of quartz mills—Continued.

Locality.	Name of mill.	Metal.	Horse power.		No. stamps.
			Steam.	Water.	
CLEAR CREEK COUNTY.*					
Georgetown	Palmer and Nichols	Silver	35	......	10
Georgetown	Brown Silver Mining Company	Silver	35	......	20
Georgetown	Stewart's	Silver	35	......	20
Idaho	Whale Company	Gold & Silver	......	......	......
Georgetown	Wilson and Cass Co	Silver	......	100	20
Bakerville	Baker Gold and Silver Mining Companies	Gold & Silver	......	......	20
BOULDER COUNTY.					
	Davidson & Smith	Gold	125	......	50
PARK COUNTY.					
	Pioneer Mining Company	Gold	70	......	15
LAKE COUNTY.					
	Yankee Blade	Gold	22	20	20
	Hayden & Son	Gold	......	20	9
	Treasury Mining Company	Gold	......	......	15

* The list of mills in Clear Creek, Boulder, Park, and Lane Counties, Colorado, is imperfect, account having been taken of such only as were running in the summer of 1870; and even of these, I fear, (full returns not yet having arrived,) a number have been omitted. The census returns, however, do not even contain as many as are here given. Several costly mills (idle) are at Empire.

List of quartz mills—Continued.

WYOMING.

Location.	Name of mill.	Metal.	Horse-power.		No. stamps.
			Steam.	Water.	
South Pass City	Hermit	Gold		Water	6
South Pass City	Miner's Delight	Gold	40		10
Atlantic City	Anthony & Irwin's	Gold	8		10
	Elkhorn	Gold			10
South Pass City	Young America*	Gold			10
	Kidder & Mason	Gold			10
	Rice & Co	Gold			10
	Collins & Co	Gold			10
	Wheeler, Hall & Jeffers	Gold			20
	Wheeler, Hall & Jeffers	Gold			20
	Mammoth Company	Gold			20

*This mill was burned down late in the fall of 1870.

PART III.

MISCELLANEOUS.

CHAPTER XVII.

NARROW-GAUGE RAILWAYS.

The art of mining may be said to have given birth to the railway system. Not only was the steam-engine primarily employed in mining, and developed in obedience to the necessities of that industry, but long before the use of steam as a motor the idea of traction upon tramways was originated, so far as we can now discover, in mines. It dates back, according to some authorities, to the Egyptians, who made use of this auxiliary in their quarries. But mining has scarcely reaped the full benefit of the combination of steam-power and rails, which has been utilized to so astonishing an extent in commerce and travel. Mines are generally located in more or less mountainous districts, presenting to the railway engineer unusual difficulties of grade and curve, and thus enhancing the cost of construction, while they offer in return a comparatively small amount of remunerative traffic. Railways, on the other hand, have continually tended toward forms of construction involving greater cost and requiring greater income for their profitable maintenance, and have thus been almost excluded from the immediate neighborhood of many mining districts. The coal and iron mines, the products of which are bulky and give rise directly and indirectly to a vast transportation business, form exceptions to this rule.

Recently, however, the attention of engineers has been called to two systems of railway construction, which put a new face upon the problems involved.

The first of these is the center-rail system, illustrated in the Mont Cenis Railway, which was opened in June, 1868. This method is applicable to mountain passes which have hitherto been considered inaccessible to the locomotive; and the road just mentioned has proved that trains of passengers and goods may thus be safely carried upon gradients and curves which would have previously been considered perilous or impracticable. Up to September, 1870, its trains had run more than two hundred thousand miles, and transported between France and Italy more than one hundred thousand passengers, without injury to a single person. It cannot be claimed for this plan that the direct cost of traction is very small. On the Mont Cenis road, it is reported to have been about 97 cents per train-mile; but there were mechanical defects in the construction of the engines, which will hereafter be avoided on similar lines, and it is believed that the cost of traction can be reduced to half the above sum. Probably the best that can be expected is, that a center-rail line over a difficult country may be maintained and operated at a cost not exceeding that of the maintenance and operation of a line for ordinary engines over the same region; the latter being of course much longer. The principal saving, therefore, is in the original cost of construction; and this might be vast in amount. In fact, we may reasonably presume that ordinary road-beds would never be commercially or financially practicable in most places where the center-rail system will be used.

Mr. J. B. Fell, civil engineer, read before the Liverpool meeting of the British Association a paper on the application of this system to a railway in Brazil now under construction.

It commences at the terminus of the Canta Gallo Railway, crosses the Serra at an elevation of 3,000 feet above the Canta Gallo line, and terminates at the town of Novo Friburgo, a distance of twenty miles. In some of its principal features this railway resembles the summit line of the Mont Cenis, the gradients for the passage of the Serra over a distance of ten miles being principally from one in twenty to one in twelve, and the curves by which the line winds round the spurs or counter forts of the mountain being, for a considerable portion of it, from 40 to 100 meters radius. The narrow gauge of 1.1 meters has also been adopted. In other features, however, there is an important difference between these two center-rail lines. The concession for the Mont Cenis was but temporary, terminating on the completion of the great tunnel, and the railway is laid on the existing public road, whereas the Canta Gallo line will be permanent, and the works will be so constructed as to be specially adapted to its requirements. It will not have to contend with the difficulties of an Alpine climate; and, profiting by the experience of two years' working on the Mont Cenis, it will have the advantage of important improvements which have been made in the engines, carriages, and permanent way during that period. Consequently, the Canta Gallo, and other similar lines now being or about to be commenced, have the interest of marking an important development of the capabilities and advantages of the center-rail system as applied to the construction and working of mountain railways.

In the new engines for the Canta Gallo line, it is proposed to dispense with the toothed wheels, and substitute for them a system of direct driving by connecting rods. The power of adhesion will also be considerably increased. These new engines will have the advantage of being able to run at a speed of from twenty to thirty miles an hour upon the ordinary gradients of the line, and of taking their loads up the mountain section at a diminished speed of from eight to ten miles an hour. In an economic point of view, the result of the application of the center-rail system to the Canta Gallo Railway will be as follows: The cost of construction, assuming it to be as estimated, about £300,000, would be at least doubled if made on gradients upon which ordinary engines could work. In this case the cost of traction and maintenance for a center-rail line will not be greater than for a line with ordinary gradients passing over the same country. The clear saving, therefore, effected by employing the center-rail system is at least £300,000, and the construction of a valuable line of railway has been rendered possible, which would otherwise have been commercially and financially impracticable. Mr. Fell mentioned a somewhat similar line of railway under consideration by the Indian government, from the port of Karwar to Hoobie, in the southern Mahratta country, both by way of the Arbyle and the Kyga Ghats. The distance is seventy miles, and it is proposed to employ the center rail for a length of about ten miles upon gradients of one in twenty for the passage of the Ghat, by which a saving would be effected of about £500,000. The cost at the present time of the transport of cotton and other produce over the ninety miles is stated to be £235,000 per annum, and there is in addition the disadvantage of not being able to convey the whole crop to the port of shipment before the rainy season sets in; a large portion of it has consequently to be housed and kept until that is over. Negotiations are going on with the government local authorities and people interested for the construction of center-rail lines in Italy from the Adriatic to Macerata, and crossing the Apennines to Foligno from Florence to Faenza, and for three branch railways in the Neapolitan States; in France, from Chambery to St. Andre du Gaz

and Lyons direct, crossing the Col de l'Epine; in Switzerland, for the passage of the Simplon; and in Spain, for lines from Leon to Corunna and Gion. The concession for the Mont Cenis Railway expires on the opening of the tunnel line; and when that period arrives, it has been proposed to remove it to one of the neighboring mountain passes, where it would have a permanent life. At the time the concessions were granted, it was considered that the line would be worked for ten, or at least seven years. The progress of the great tunnel has, however, been so much accelerated, that it is stated the tunnel line may possibly be opened for traffic by the end of 1871. In that case, and taking into a count the difficulties of all kinds with which the enterprise has had to contend, the Mont Cenis Railway can only be regarded as an experimental line and the pioneer of a system destined to confer the benefits of cheap and safe communication between many countries separated by mountain ranges hitherto impassable by railways and locomotive engines.

Of still wider importance and application is the so-called narrow-gauge system. The center rail may be said to involve this, since the localities in which it is likely to be employed are generally such as exclude the broader gauges by reason of their cost in grading; but the narrow-gauge principle itself is, of course, quite independent of the other. At the meeting of the British Association already referred to, Mr. R. F. Fairlie, civil engineer, read a paper on the gauge for the "railways of the future." I quote the substance of it, as reported in the newspapers at the time:

The object of this paper was to advance a new argument in favor of the use of a narrow gauge in the construction of railways, founded upon a comparison of the amount of weight hauled, for the same amount of paying traffic, over a railway of 3-foot gauge and a railway of the English "narrow," or 4-foot 8½-inch gauge. Although maintaining that the principle of his argument applied to passenger traffic, and that the cost of working a railway, or, in other words, the proportion of non-paying to paying weight, (as far as this is independent of management,) is increased exactly in proportion as the rails are farther apart, because a ton of materials disposed upon a narrow gauge is stronger as regards its carrying power than the same weight when spread over a wider basis, the author on the present occasion went into detail only with regard to the conveyance of goods; and he selected the London and Northwestern Raiway as his illustration of the effects of the 4-foot 8½-inch gauge, on the ground that its management is so good that the defects in its working must be wholly traceable to its construction. He undertook to show that this line, if made of a 3-foot gauge, would accommodate the whole of its present goods traffic as well as at present, and would do so at half the present cost, with half the present tonnage and motive power, and with half the present wear and tear of rails, so that the expense now being incurred for the construction of a third track would be rendered unnecessary. Assuming that the present goods traffic, independently of minerals, amounts to ten millions of tons per annum, and that the non-paying weight of trucks by which these goods are hauled amounts to the low estimate of forty millions of tons more, (seventy millions being nearer the truth,) there results a total gross weight hauled by the locomotives of fifty millions of tons at an average speed of twenty-five miles an hour. The earnings for the goods traffic on this line are 6*s.* 3*d.* per train-mile, which, at an average rate all round of 1¼*d.* per ton per mile, would give about 50 tons as the paying weight and 225 tons as the gross weight hauled per train-mile. Dividing these 225 tons into the fifty millions, gives 196,089 trains, which, being divided by 312 working-days of a year, gives 626 merchandise trains over all parts of the Northwestern Railway in the twenty-four hours. The company's balance-sheet shows that each net ton produces about 4*s.* 3*d.*, which, at 1¼*d.* per ton per mile, makes the average distance traversed by each ton to be about thirty-eight miles; so that as each ton of the total weight hauled runs thirty-eight miles, and the entire length of line worked is one thousand four hundred and thirty-two miles, it follows that there must be, on an average, thirty-seven merchandise trains distributed over the total length. Dividing by this number the total number of trains per day of twenty-four hours, gives an average of over seventeen trains per day running on each mile of the line. Having reached this conclusion, it becomes possible to see how it would affect the question if the gauge of the line were 3 feet instead of 4 feet 8½ inches. In the first place, the same or a greater speed could be maintained, say up to thirty-five or forty miles an hour. On the 4-foot 8½-inch gauge the proportion of non-paying to paying load has been taken at four to one,

although it has proved largely in excess of this. The wagons employed average four tons in weight, so that on this reckoning each wagon carries one ton for every mile it runs. The wagons for a line of 3-foot gauge weigh each one ton, and carry a *maximum* load of three tons. Supposing that the same number of wagons and trains were run on the narrow gauge as on the broad, it follows that the average one ton of merchandise now carried would easily be taken in a wagon weighing one ton instead of four tons, and that the gross load passing over the line for one year would be only twenty millions of tons instead of fifty millions; while the same amount of paying weight would be carried in either case; that is, the small wagons which are capable of carrying three times the weight of goods now actually carried in a four-ton wagon would only have to carry one-third of that quantity, and would produce the same paying load as the heavier wagons, and, as the haulage cost is precisely the same whether the tons hauled consist of paying or non-paying load, it follows that this expense would be reduced to two-fifths of what it now is. If the same number of trains were to run per day, the weight of each would be reduced from 225 tons to 102 tons; or, if the same gross weight of train was employed, the number of trains per day would be reduced from 626 to 250. If there should be sufficient traffic to load the narrow-gauge wagons in such a way as to require the same number and weight of trains that are now worked, the result would be that without increasing by one penny the cost of haulage and of the permanent way of expenses, the 3-foot gauge would carry a paying load of twenty-five millions of tons as against the ten millions now carried. Here, then, we have established the fact that, as far as capacity goes, the narrow gauge is superior to the broad one. The former can produce twenty-five millions net out of a gross tonnage of fifty millions; while the latter, to produce the same result, if continued to be worked as it now is, would require that one hundred and twenty-five million tons should be hauled, and that at an increased cost in the same proportion of one hundred and twenty-five millions to fifty millions. The rest of the paper was devoted to an application of these figures to the question of the best gauge for Indian and colonial railways, and to the argument that such railways might be made cheaply and efficiently on a 3-foot gauge, so as to charge a reasonable tariff and to afford a satisfactory return.

I think Mr. Fairlie has pushed the argument in behalf of the narrow gauge further than an impartial judgment will follow. It is scarcely fair to take actual working results on one hand and sanguine expectations on the other as the basis of comparison, and to ignore all considerations other than those of paying and non-paying weight. But there is no doubt, whatever may be *the* gauge of the "railways of the future," that the narrow gauges will play an important part, and that their economical advantages will be more closely studied than heretofore. Especially in the United States, where the peculiarly American system of pushing railroads in advance of settlement and traffic has been so vigorously and successfully followed, this subject possesses a special interest.

There are few questions of more practical and pressing importance at the present day than the best means to be adopted for extending our railroad system (carrying with it as it does fresh life and energy into all the districts which it penetrates) into the Territories and other parts of this vast Union, where the traffic to be expected, at any rate, for years to come, cannot be such as to warrant a large capital expenditure.

The following information was kindly furnished me by Sir Charles Fox & Sons, the well-known civil engineers of London, who have for many years been actively engaged in practically working out a similar problem in Australia, India, and Canada.

Their object has been to construct railroads which, while very economical in first cost, should be substantially built and equipped, and therefore operated and maintained at a moderate percentage of the gross income.

Mr. Carl Pihl, the engineer of the government railway of Norway, has also for some years been carrying out very successfully a system almost identical with that under review.

The question of gauge is one which requires to be determined after careful investigation of the circumstances in each case. Where a standard national gauge exists, caution must of course be exercised in introducing any diversity; and yet it may, upon examination, be found that to adhere in

all cases to the gauge suitable for trunk-roads would be to check, nay, even to prevent, the construction of many tributary or branch roads, in themselves most necessary for the development of the country. Thus, in the vast empire of India, where the trunk-roads have the 5-foot 6-inch gauge, the government is seriously and favorably entertaining the question of adopting a much narrower gauge for the tributary roads, to open up the country.

With the above reservation, Sir Charles Fox & Sons, and others interested in this question, have found, after an experience spread over many years, that the most economical gauge for such tributary roads which can be used with advantage is that of 3 feet 6 inches. A broader gauge than this is, in their opinion, for speeds of twenty-five miles an hour and moderate traffic, quite unnecessary, and of course involves additional outlay, especially if the country is of a hilly nature. To use, on the other hand, a narrower gauge than 3 feet 6 inches is likewise objectionable, and especially so where wood is the fuel chiefly employed, as on very narrow gauges it becomes impossible to use either boilers or fire-boxes of such dimensions as to give satisfactory results.

The following are given as examples of railroads which have been built, or are now in progress of construction, upon this gauge:

Examples and cost in gold, including in each case stations, rolling-stock, engineering, and all management expenses.

1st. The Queensland Railways, Australia. Length, two hundred and twenty-two miles; gauge, 3 feet 6 inches. Wages: Skilled laborer, \$2 50 to \$3 10; ordinary, \$1 50 to \$1 75. Average cost per mile, \$32,000.

2d. The railway from Conyeveram to Arconnur, India. Length, nineteen miles; gauge, 3 feet 6 inches. (Land and portion of road-bed given by government.) Materials chiefly sent out from England. Rails, 35¼ pounds; iron. Average cost per mile, \$19,000.

3d. The Toronto, Grey and Bruce, and the Toronto and Nipissing Railways, Canada. Length of first section, one hundred and ninety-three miles; gauge, 3 feet 6 inches. Wages: Ordinary laborer, \$1 to \$1 50. Average cost per mile, \$14,150.

4th. The government railways, Norway, (constructed by Carl Pihl, civil engineer.) Length, one hundred and six miles; gauge, 3 feet 6 inches. (Rails and many other materials sent out from England.) First, through easy country, \$15,900 per mile; second, through heavy country, \$23,700 to \$26,150 per mile.

It will be seen that, the two first of these principles being conceded, it at once becomes possible to construct a thoroughly substantial track with rails not weighing more than from 30 to 40 pounds per linear yard, provided that the ties are laid sufficiently close, the rails well fished at the joints, and an ample supply of ballast provided.

The speed of twenty-five miles an hour is found in practice to be more than sufficient for tributary roads. A load of four tons per wheel is sufficient to enable the passenger and freight cars to be of ample dimensions for convenience of traffic.

The passenger-cars of latest design are of the usual American type, 32 feet long exclusive of platforms, and 8 feet 6 inches wide, carrying very comfortably thirty-two passengers. Their center of gravity being very low, they run with great steadiness. The box-cars are 15 feet long and 8 feet 6 inches wide. The platform-cars are 24 feet long and 8 feet 6 inches wide, and carry ten tons, their own weight being only five tons.

It will thus be seen that the non-paying load, or dead weight, is re-

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

ings were exhibited of a road recently constructed as a branch line for carrying iron ore from the Park-house mines to the Furness Railway in North Lancashire. The gauge of this line is 8 inches, and the length about one mile. It is carried at various elevations from 3 to 20 feet over an undulating country, passing over the fences, roads, and water-courses without requiring the construction of earthworks or masonry. The structure consists of a narrow beam of wood, supported at intervals on a single row of pillars. The narrow gauge is practically made equivalent to a broader one by the steadying power of guide-rails fixed on the sides of the beam and below the carrying rails. The wagons are suspended from the axles, and by this means the center of gravity is brought low. They are also furnished with horizontal wheels, which run upon the guide-bars, and thus maintain the equilibrium of the carriages, and render it almost impossible for them to leave the rails. The Park-house line will have a traffic of 50,000 tons per annum. The cost has been £1,000 per mile, without stations or rolling-stock. It is worked by a stationary engine and endless wire rope. The saving effected in the cost of transport will be at least 6*d.* per ton upon the distance of one mile. In Switzerland application has been made to the government of the canton Vaud for a passenger line on this principle from the town of Lausanne to the lake of Geneva. Plans have also been laid before the war office for accelerating military transport in foreign countries, and before the governor-general of India for the construction of cheap branches from the trunk lines in that country. The gauge of these railways may be from 6 to 18 inches. They may be made of wood or iron, or of the two combined, and may be worked by either stationary engines or by locomotives of a form specially designed for the purpose. They have the advantages of being economical in both construction and working; they occupy but little land and cause no severance; they may be erected with great rapidity, and, being portable, may be removed when no longer required and reërected in another locality. Before the war commenced, an offer was made to the French government to construct one of these portable railways to supply their army with from 1,000 to 3,000 tons of ammunition and provisions per day. The work would have been undertaken by a gentleman in Paris, who, with a force of 2,500 men, would have constructed from four to five miles of railway per day, following the advance of the army into Germany. The result has, however, shown how little such a provision was needed.*

* Since the foregoing chapter was compiled the available data on the subject have been greatly augmented, and the narrow-gauge system has been eagerly taken up by American enterprise. I hear of proposed roads on this plan in many parts of the West, and probably before another year has elapsed many such undertakings will be in progress. At the present moment, however, I cannot distinguish between rumors, or sanguine schemes, and facts.

CHAPTER XVIII.

THE MINING LAW.

The following are the two acts of Congress under which the present administration of the mining law is conducted, so far as the United States Government is concerned. They comprise, therefore, all the regulations which are universal in their application, and superior to the local and variable rules established by State and territorial legislation, or by the "laws" and "customs" of mining districts:

AN ACT granting the right of way to ditch and canal owners over the public lands, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the mineral lands of the public domain, both surveyed and unsurveyed, are hereby declared to be free and open to exploration and occupation by all citizens of the United States, and those who have declared their intention to become citizens, subject to such regulations as may be prescribed by law, and subject also to the local customs or rules of miners in the several mining districts, so far as the same may not be in conflict with the laws of the United States.

SEC. 2. *And be it further enacted,* That whenever any person, or association of persons, claim a vein or lode of quartz, or other rock in place, bearing gold, silver, cinnabar, or copper, having previously occupied and improved the same according to the local customs or rules of miners in the district where the same is situated, and having expended in actual labor and improvements theron an amount of not less than one thousand dollars, and in regard to whose possession there is no controversy or opposing claim, it shall and may be lawful for said claimant, or association of claimants, to file in the local land office a diagram of the same, so extended laterally or otherwise as to conform to the local laws, customs, and rules of miners, and to enter such tract and receive a patent therefor, granting such mine, together with the right to follow such vein or lode, with its dips, angles, and variations to any depth, although it may enter the land adjoining, which land adjoining shall be sold subject to this condition.

SEC. 3. *And be it further enacted,* That upon the filing of the diagram as provided in the second section of this act, and posting the same in a conspicuous place on the claim, together with a notice of intention to apply for a patent, the register of the land office shall publish a notice of the same in a newspaper published nearest to the location of said claim, and shall also post such notice in his office for the period of ninety days; and after the expiration of said period, if no adverse claim shall have been filed, it shall be the duty of the surveyor general, upon application of the party, to survey the premises and make a plat thereof, indorsed with his approval, designating the number and description of the location, the value of the labor and improvements, and the character of the vein exposed; and upon the payment to the proper officer of five dollars per acre, together with the cost of such survey, plat, and notice, and giving satisfactory evidence that said diagram and notice have been posted on the claim during said period of ninety days, the register of the land office shall transmit to the General Land Office said plat, survey, and description, and a patent shall issue for the same thereupon. But said plat, survey, or description shall in no case cover more than one vein or lode, and no patent shall issue for more than one vein or lode, which shall be expressed in the patent issued.

SEC. 4. *And be it further enacted,* That when such location and entry of a mine shall be upon unsurveyed lands, it shall and may be lawful, after the extension thereto of the public surveys, to adjust the surveys to the limits of the premises according to the location and possession and plat aforesaid; and the surveyor general may, in extending the surveys, vary the same from a rectangular form to suit the circumstances of the country and the local rules, laws, and customs of miners: *Provided,* That no location hereafter made shall exceed two hundred feet in length along the vein for each locator, with an additional claim for discovery to the discoverer of the lode, with the right to follow such vein to any depth, with all its dips, variations, and angles, together with a reasonable quantity of surface for the convenient working of the same, as fixed by local rules: *And provided further,* That no person may make more than one location on the same lode, and not more than three thousand feet shall be taken in any one claim by any association of persons.

SEC. 5. *And be it further enacted,* That as a further condition of sale, in the absence of necessary legislation by Congress, the local legislature of any State or Territory

may provide rules for working mines involving easements, drainage, and other necessary means to their complete development; and those conditions shall be fully expressed in the patent.

SEC. 6. *And be it further enacted,* That whenever any adverse claimants to any mine, located and claimed as aforesaid, shall appear before the approval of the survey, as provided in the third section of this act, all proceedings shall be stayed until final settlement and adjudication, in the courts of competent jurisdiction, of the rights of possession to such claim, when a patent may issue as in other cases.

SEC. 7. *And be it further enacted,* That the President of the United States be, and he is hereby, authorized to establish additional land districts, and to appoint the necessary officers under existing laws, wherever he may deem the same necessary for the public convenience in executing the provisions of this act.

SEC. 8. *And be it further enacted,* That the right of way for the construction of highways over public lands, not reserved for public uses, is hereby granted.

SEC. 9. *And be it further enacted,* That whenever, by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes, have vested and accrued and the same are recognized and acknowledged by the local customs, laws, and the decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes aforesaid is hereby acknowledged and confirmed: *Provided, however,* That whenever, after the passage of this act, any person or persons shall, in the construction of any ditch or canal, injure or damage the possession of any settler on the public domain, the party committing such injury or damage shall be liable to the party injured for such injury or damage.

SEC. 10. *And be it further enacted,* That wherever, prior to the passage of this act, upon the lands heretofore designated as mineral lands, which have been excluded from survey and sale, there have been homesteads made by citizens of the United States, or persons who have declared their intention to become citizens, which homesteads have been made, improved, and used for agricultural purposes, and upon which there have been no valuable mines of gold, silver, cinnabar, or copper discovered, and which are properly agricultural lands, the said settlers or owners of such homesteads shall have a right of preëmption thereto, and shall be entitled to purchase the same at the price of one dollar and twenty-five cents per acre, and in quantity not to exceed one hundred and sixty acres; or said parties may avail themselves of the provisions of the act of Congress approved May twenty, eighteen hundred and sixty-two, entitled "An act to secure homesteads to actual settlers on the public domain," and acts amendatory thereof.

SEC. 11. *And be it further enacted,* That upon the survey of the lands aforesaid, the Secretary of the Interior may designate and set apart such portions of the said lands as are clearly agricultural lands, which lands shall thereafter be subject to preëmption and sale as other public lands of the United States, and subject to all the laws and regulations applicable to the same.

Approved July 26, 1866.

AN ACT to amend "An act granting the right of way to ditch and canal owners over the public lands, and for other purposes."

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act granting the right of way to ditch and canal owners over the public lands, and for other purposes, approved July twenty-six, eighteen hundred and sixty-six, be, and the same is hereby, amended by adding thereto the following additional sections, numbered twelve, thirteen, fourteen, fifteen, sixteen, and seventeen, respectively, which shall hereafter constitute and form a part of the aforesaid act.

SEC. 12. *And be it further enacted,* That claims, usually called "placers," including all forms of deposit, excepting veins of quartz, or other rock in place, shall be subject to entry and patent under this act, under like circumstances and conditions, and upon similar proceedings, as are provided for vein or lode claims: *Provided,* That where the lands have been previously surveyed by the United States, the entry in its exterior limits shall conform to the legal subdivisions of the public lands, no further survey or plat in such case being required, and the lands may be paid for at the rate of two dollars and fifty cents per acre: *Provided further,* That legal subdivisions of forty acres may be subdivided into ten-acre tracts; and that two or more persons, or associations of persons, having contiguous claims of any size, although such claims may be less than ten acres each, may make joint entry thereof: *And provided further,* That no location of a placer claim, hereafter made, shall exceed one hundred and sixty acres for any one person or association of persons, which location shall conform to the United States surveys; and nothing in this section contained shall defeat or impair any *bona-fide* preëmption or homestead claim upon agricultural lands, or authorize the sale of the improvements of any *bona-fide* settler to any purchaser.

SEC. 13. *And be it further enacted,* That where said person or association, they and

their grantors, shall have held and worked their said claims for a period equal to the time prescribed by the statute of limitations for mining claims of the State or Territory where the same may be situated, evidence of such possession and working of the claims for such a period shall be sufficient to establish a right to a patent thereto under this act, in the absence of any adverse claim: *Provided, however*, That nothing in this act shall be deemed to impair any lien which may have attached in any way whatever to any mining claim or property thereto attached prior to the issuance of a patent.

SEC. 14. *And be it further enacted*, That all *ex-parte* affidavits required to be made under this act, or the act of which it is amendatory, may be verified before any officer authorized to administer oaths within the land district where the claims may be situated.

SEC. 15. *And be it further enacted*, That registers and receivers shall receive the same fees for services under this act as are provided by law for like services under other acts of Congress; and that effect shall be given to the foregoing act according to such regulations as may be prescribed by the Commissioner of the General Land Office.

SEC. 16. *And be it further enacted*, That so much of the act of March third, eighteen hundred and fifty-three, entitled "An act to provide for the survey of the public lands in California, the granting of preëmption rights, and for other purposes," as provides that none other than township lines shall be surveyed where the lands are mineral, is hereby repealed. And the public surveys are hereby extended over all such lands: *Provided*, That all sub-dividing of surveyed lands into lots less than one hundred and sixty acres may be done by county and local surveyors at the expense of the claimants; *And provided further*, That nothing herein contained shall require the survey of waste or useless lands.

SEC. 17. *And be it further enacted*, That none of the rights conferred by sections five, eight, and nine, of the act to which this act is amendatory shall be abrogated by this act, and the same are hereby extended to all public lands affected by this act; and all patents granted or preëmption or homesteads allowed shall be subject to any vested and accrued water rights, or rights to ditches and reservoirs used in connection with such water rights as may have been acquired under or recognized by the ninth section of the act of which this act is amendatory. But nothing in this act shall be construed to repeal, impair, or in any way affect the provisions of the "Act granting to A. Sutro the right of way and other privileges to aid in the construction of a draining and exploring tunnel to the Comstock lode, in the State of Nevada," approved July twenty-fifth, eighteen hundred and sixty-six.

Approved July 9, 1870.

The following instructions issued by the Commissioner of the General Land Office to registers and receivers, in relation to the survey and entry of mining claims under the provisions of these acts, sufficiently explain the present condition and construction of the law:

DEPARTMENT OF THE INTERIOR,
General Land Office, August 8, 1870.

GENTLEMEN: The original mining act of July 26, 1866, (United States Statutes, vol. 14, p. 251,) having been amended in adding to its provisions additional sections twelve to seventeen inclusive, by the act of Congress, approved July 9, 1870, it becomes my duty to prescribe for your information and observance the following regulations, to wit:

1st. By the twelfth section of the amendatory act, placer claims, including all forms of deposit, excepting veins of quartz or other rock in place, are made subject to entry and patent under similar circumstances, conditions, and like proceedings as contemplated in the original act for vein or lode claims.

Placer claims on surveyed lands are authorized to be entered by legal subdivisions, no special survey or plat in such case being required, at the rate of $2 50 per acre. In regard to placer claims, however, the amendatory law restricts their extent, in respect to locations made after the date of its passage, to not exceeding one hundred and sixty acres for any one person, or association of persons; such location being required to conform to the Government surveys, and not to interfere with any *bona-fide* preëmption or homestead claims upon agricultural lands.

2d. The act further provides for the subdivision of forty-acre legal subdivisions into ten-acre tracts, and authorizes two or more persons, or association of persons, having contiguous claims of any size, although less than ten acres each, to make joint entry of such minor subdivisions, all *bona-fide* preëmption or homestead claims upon agricultural lands being protected by law. The surveyors general are therefore hereby authorized to have such subdivisions into ten-acre tracts made by their deputies when applied for by claimants, numbering each ten-acre tract with consecutive numbers of claims in the township, as in the case of other mineral surveys, and if the service is performed by county and local surveyors, as authorized by the sixteenth section of the amendatory act, it will be the duty of the surveyor general to verify the surveys so

executed, and if found correctly done, to adopt the same and certify the fact, appending his approval as in cases where surveys are made under his own direction. The expense of such subdividing is required to be defrayed by the mining claimants.

3d. In the thirteenth section it is declared that in the absence of any adverse claim where said person or association, they and their grantors, shall have held and worked their said claims for a period equal to the time prescribed by the statute of limitations for mining claims of the State or Territory where the same may be situated, evidence of such possession and working of the claims for such period shall be sufficient to establish a right to a patent thereto, subject to any lien which may have attached to such claim prior to the issue of said patent.

The foregoing provision is construed to apply as well to lode as to placer claims, and should lessen the amount of proof usually required to establish a right to a patent.

4th. In the fourteenth section it is provided that all *ex-parte* affidavits required under the original and amendatory acts may be verified before any officer authorized to administer oaths within the land district in which the claims are situated.

5th. By the fifteenth section it is declared that registers and receivers are entitled to the same fees for services in mining cases as are provided by law for like services under other acts of Congress, the rates of allowance being specifically given in our circular dated July 25, 1870.

6th. By the sixteenth section the interdict placed by the act of March 3, 1853, "that none other than township lines shall be surveyed where the lands are mineral," is repealed; this provision of law being referable to surveys in California only; the extension of the lines of future surveys over the lands mentioned in this section applies exclusively to that State. The requirement, however, in the last proviso of the same section, "that nothing herein contained shall require the survey of waste or useless lands," is a principle of general application, and surveyors general will refrain from extending the lines of public surveys over such waste lands, which are considered to be those covered by alkali to a depth calculated to prevent the growing of crops, moving sand, or other sandy plains of great extent, and abrupt or snowy mountains not known to contain mineral deposits.

7th. Section seventeen authorizes the extension of the rights conferred by sections 5, 8, and 9 of the original mining act, to all public lands affected by this law, and subjects all patents granted, or preëmptions or homesteads allowed, to any vested or accrued water rights, or rights to ditches and reservoirs used in connection with such water rights as may have been acquired under, or recognized by, the said ninth section, said section declaring further that nothing in the act shall be construed to repeal, or in any way affect, the act granting the right of way and other privileges to aid in the construction of a draining and exploring tunnel to the Comstock lode in the State of Nevada, approved July 25, 1866, (United States Statutes, volume 14, p. 242.)

8th. The per-diem allowance to deputy surveyors, including all expenses of assistants for surveys of mineral claims, as stipulated in our circular letter of January 14, 1867, has been in several cases found inadequate, and that, consequently, parties in order to induce deputies to make the surveys have found it necessary to pay additional sums as on private account. To avoid such results the surveyors general are hereby authorized to increase the maximum per-diem allowance according to the difficulty of the service, taking care, however, to have the work performed on the most economical scale by skillful and responsible surveyors, and in no case to exceed a maximum of $20 per day.

In each case where an allowance is made of over $10 per day, the reasons showing the necessity for doing so must be stated in the contract and then reported to this office, and it must be understood that no extra compensation, under any circumstances whatever, is to be exacted or received by the deputy under penalty of forfeiting the contract and exclusion from the public surveying service.

SPECIAL INSTRUCTIONS RELATIVE TO OBTAINING PATENTS FOR MINING CLAIMS.

With reference to the proceedings necessary to obtain patents for lode and placer claims under the provisions of the acts of Congress above-mentioned, the following is communicated:

9th. The mining enactments limit the right to apply for and receive patents for mining claims to claimants.

First. Who have occupied and improved their claims according to the local customs or rules of miners, or—

Second. Who have by themselves or their grantors, held and worked their claims for a period equal to the time prescribed by the statute of limitations for mining claims of the State or Territory where the same may be situated.

Third. Who have expended in actual labor and improvements upon their respective claims an amount of not less than $1,000, and—

Fourth. In regard to whose possession there is no controversy or opposing claim.

Unless, therefore, applicants for mining patents are properly within these require-

ments they are not in a condition to avail themselves of the privileges extended by the laws referred to.

THE APPLICATION.

10th. This must be in writing, and must be filed in the office of the register and receiver of the land district in which the claim lies. It must distinctly state the name of the applicant, and whether the claim is applied for by an individual, an association, or an incorporation; the name and extent of the claim; the character of the ore; the mining district, county, and State; the date of its original location according to the mining customs; where the same was recorded; whether the applicant claims as a locator or purchaser; give a description of the premises claimed, and the nature of the improvements made or labor performed, and finally the application should state that the claimant has posted a "diagram" of the claim in a conspicuous place thereon, together with notice of his intention to apply for a patent, giving the date of such posting.

11th. With the above application the claimant must file a copy of the "diagram" posted on the claim, which diagram must represent the boundaries of the premises, as fixed by the local laws, customs, or rules of miners; and, when the claim lies upon surveyed land, it must also show its relation to the public surveys.

12th. Diagrams of placer claims upon surveyed lands must represent the subdivision of the public lands which the claimant desires to enter, as the act requires such entries, in their exterior limits, to conform to such legal subdivisions.

13th. With said diagram must be filed a copy of the "notice" posted upon the claim.

This should state the name of the claimant, describe the claim, give the names of adjoining claims, or if none adjoin, the names of the nearest claims; state whether it is a placer or rock claim, if the former the approximate area, if the latter, the estimated extent of surface ground, and the number of feet claimed on the course of the vein, distinctly stating the name of the lode and the character of the vein exposed; the mining district, county, and State in which it lies; whether upon surveyed or unsurveyed lands; if the former, in what section, township, and range; if the latter, the location of the claim relatively to some well-known natural object or landmark in the vicinity, and, finally, the notice should state that it is the intention of the claimants to apply for a patent for the premises therein designated, and upon which it is posted.

14th. There should also be filed with the application satisfactory evidence that the applicant has the possessory right to the claim agreeably to the local laws or customs of miners. This should consist of a certified copy of the laws or customs of the miners of the district in force at the date of the location of the claim, and of a certificate under seal, of the county or mining recorder, giving a copy of the record of the original location of the claim, with name or names of the locators, and if the applicant claims as a purchaser, an abstract of title should be filed, tracing the right of possession from the original locators to the applicant for patent. Where applicants furnish satisfactory evidence that they and their grantors have held and worked their claims for a period equal to the time prescribed by the statute of limitations of mining claims of the State or Territory where the same may be situated, such evidence being sufficient to establish a right to a patent for a claim so held and worked, upon compliance with the other provisions of the law and instructions, the proofs enumerated under this subdivision, (14,) of the instructions are not required.

15th. Proof of citizenship is required. Where the applicant is a corporation, a copy of its charter or certificate of incorporation may be filed in lieu of evidence of citizenship. In case, however, the applicant is an individual or an association of persons unincorporated, affidavits of citizenship, or of having filed declarations of intention to become citizens, should be filed.

16th. Upon filing these papers the register and receiver will give the same careful examination, and if found to be regular the register will order the publication of the "notice" for ninety days in a newspaper published nearest the location of the claim, but before ordering such publication, the register will, in future, require the claimant to enter into an agreement with the publisher, to the effect that no claim or demand shall be made against the United States for the payment of such publication, and the register will decline to order the publication until such written agreement shall have been filed in his office. The cost of the publication of notice will, therefore, not be estimated by the surveyor general in future cases.

17th. The register will also post copies of the said "notice" and "diagram" in his office for ninety days, and upon forwarding the case to this office will certify that they were so posted.

18th. On the expiration of the ninety days, the claimant or his duly authorized agent, must file with the register his own affidavit, supported by that of at least one other person cognizant of the fact that said "notice" and "diagram" were posted in a conspicuous place upon the claim for the period of ninety consecutive days, giving

the date of the same. The affidavit of the publisher must also be filed to the effect that the "notice," a printed copy of which should be attached, was published in his newspaper for ninety days, giving the date on which such publication commenced and ended, and that he has received payment in full for the same.

19th. These affidavits may be taken before the register and receiver or any officer authorized to administer oaths within their district, but if taken before a magistrate without an official seal, his official character must be authenticated under seal by the county clerk in the usual manner.

20th. If all the proof furnished is satisfactory to the register and receiver, and no adverse claim has been filed, these officers will, at the end of the ninety days, so inform the applicant for patent and the surveyor general, which last-named officer will make an estimate of the expense of surveying and platting the claim, except in the case of placer claims on surveyed land, where no further survey is required, and when the claimant shall have deposited the amount so estimated with any assistant United States treasurer or designated depository in favor of the United States Treasurer to be passed to the credit of the fund created by "individual depositors for surveys of the public lands," and shall have filed with the surveyor general one of the duplicate certificates of deposit, that officer will order the claim to be surveyed and platted in accordance with the regulations of this office governing mineral surveys, except in cases where the claimant has had a preliminary survey made by the United States deputy surveyor, for the purpose of perfecting the diagram and notice posted on the claim, in which case such preliminary survey may be platted and adopted by the surveyor general for the final survey. Copies of plat and field notes of survey are to be sent to the register and receiver and to the General Land Office, the latter accompanied by the certificate of deposit.

21st. The register and receiver will examine the returns of the survey, and, if found satisfactory, will allow the entry to be completed at the rate of $5 per acre, or fractional part of an acre, for lode claims, or $2 50 per acre, or fractional part of an acre, for placer claims, and transmit all the papers on their files bearing upon the case to the General Land Office, together with their joint opinion thereon, so that a patent may be issued if all is found regular.

22d. In regard to placer claims on surveyed land, where the claimant applies to enter one hundred and sixty acres in legal subdivisions, no survey and plat of the claim are required; the entry in that case being allowed to be completed at the local land office as soon as satisfactory proof has been made after the expiration of ninety days' notice and publication, provided no adverse claimant has appeared in the mean time.

23d. Where the claimant of a placer mine desires the subdivision of a quarter section, the service may be performed by county and local surveyors at the expense of the claimant, as required by law.

With reference to the subdivision of forty-acre into ten-acre lots, mentioned in the second section of the above instructions, supplementary decisions have been issued. The following letter gives a very liberal rule for the survey and subdivision of ten-acre lots of mineral lands, and will be readily understood by surveyors and miners. Its particular application is in the surveying of creek and cañon claims. The case which called for the ruling arose on Deer Creek, just below Nevada City, California.

DEPARTMENT OF THE INTERIOR,
General Land Office, October 20, 1870.

SIR: In reply to your letter of the 31st August last, covering one from H. S. Bradley, a deputy United States surveyor, dated the 13th of the same month and year, and addressed to yourself, I have the honor to state as follows:

Circular instructions were issued to the United States land officers by this office on the 8th of August last, in relation to the survey and entry of lode and placer claims under the provisions of the amendatory act of Congress, granting the right of way to ditch and canal owners over the public lands, and approved July 9, 1870, a copy of which is herewith inclosed.

It will be perceived on the first page of the circular, that surveyors-general were authorized to have the subdivision of forty-acre legal subdivisions into ten-acre tracts made when applied for by claimants, and at their cost; and under the twenty-third head of the same circular, the land officers were informed that placer claimants desiring the subdivision of a quarter section, the service may be performed by county and local surveyors, at the expense of the claimant, as required by the sixteenth section of the amendatory law. As to the particular method of subdividing subdivisions into ten-acre lots, I have to observe that they are susceptible of being subdivided either into square lots of ten-by-ten chains, or into lots of five-by-twenty chains, by running

measuring and marking lines in the field due east and west, or due north and south, through the legal subdivisions desired to be subdivided into ten-acre lots, and in regard to which method the surveyors-general have this day been instructed.

I am, very respectfully, your obedient servant,

JOS. S. WILSON,
Commissioner.

Hon. A. A. SARGENT, *Washington City.*

A somewhat similar case arose in Montana, in which an application for a patent for one hundred and sixty acres of surveyed placer land land was rejected by the register and receiver at Helena, for the reason that the claim in its exterior limits did not conform to the legal divisions of the public lands, as required by section 12 of the amendatory mining law of July 2, 1870. The Commissioner, upon a review of the case, reversed the decision of the register and receiver, and decided that ten-acre lots on surveyed land, in mining States and Territories, are legal subdivisions of the public lands; and that such legal subdivisions may be either 10-by-10 or 5-by-20 chains in size, to suit the case. He says:

In the case in question, it appears that the applicant desires to enter and secure a patent for the one hundred and sixty acres of surveyed land, to be segregated from the public domain in contiguous ten-acre lots, in such manner as to embrace the gulch or placer claims for which he desires a patent. There is no reason why this should not be done, if so desired, inasmuch as the second proviso to said twelfth section authorizes the subdivision of forty into ten-acre tracts, thus recognizing in mineral regions a ten-acre lot as a legal subdivision of the public lands; this provision of the law having been formed for the very just and liberal purpose of enabling miners to prove up and pay for their claims with the least possible chance of difficulty or interference with adjoining mineral or agricultural claimants. The law does not stipulate that these ten-acre subdivisions shall be in the form of a square, each side measuring ten chains, and it is held that if a ten-acre tract, one side of which is five and the other twenty-five chains, will better embrace the mining premises applied for, no objection to such claim being so surveyed should be made, provided, of course, that such surveys are not run diagonally to the lines of the regular surveys, but are parallel to the same, so that the public lands from which such tracts are segregated may be described and disposed of without confusion or difficulty. In the case under consideration, should the view of the register and receiver be sustained, the mining claimant would be compelled, if he entered the land at all, to embrace in its application four hundred instead of the one hundred and sixty acres desired by him, a large portion of which may be occupied by adjoining claimants, either for mining or agricultural purposes, or it may be barren or waste, unfit for either purpose. To require mining claimants in cases like the present to postpone making applications for patents until adjoining miners are willing to unite in making a joint entry of their respective claims, or to include in their applications large areas of worthless land to be paid for at double the minimum price of good agricultural land, would not only be a hardship upon the miners, but inconsistent with the intention of the statute.

The following bill, proposed by Senator Stewart of Nevada, passed the Senate February 8, 1871, and now awaits the action of the House:

Be it enacted, etc., That the mineral lands of the public domain, both surveyed and unsurveyed, are hereby declared to be free and open to exploration and occupation, for mining purposes, by all persons, subject to such regulations as may be prescribed by law, and subject also to the local customs or rules of miners in the several mining districts, so far as the same may not be in conflict with the laws of the United States.

SEC. 2. *And be it further enacted*, That the miners of each mining district may determine the length of their mining claims upon veins or lodes of quartz, or other rock in place, bearing gold, silver, cinnabar, lead, tin, or copper, subject to the following limitations: Claims located previous to July twenty-six, eighteen hundred and sixty-six, shall be limited as to extent along the vein or lode by the local laws or customs existing at the date of the location. Single claims located subsequent to July twenty-six, eighteen hundred and sixty-six, shall not exceed two hundred feet in length along the vein or lode, with an additional claim of two hundred feet for discovery to the discoverer of a vein or lode. Several persons may locate in common on a vein or lode, each pers on taking one claim; but no person, except the discoverer, shall locate more that one claim upon the same vein or lode, and the aggregate amount of a location in common, made subsequent to July twenty-six, eighteen hundred and sixty-six, shall not exceed three thousand feet in length along the vein or lode. No claim shall extend more than three hundred feet on each side of the middle of the vein at the surface, nor

shall any claim be limited by any mining regulation to less than twenty-five feet on each side of the middle of the vein at the surface, except where adverse rights existing at the passage of this bill shall render such limitation necessary. The end lines of each claim shall be parallel to each other, and at right angles with the general course of the vein.

SEC. 3. *And be it further enacted,* That the locators of all mining locations heretofore made, or which shall hereafter be made, on any mineral vein, lode, or ledge situated on the public domain, their heirs and assigns, where no adverse claim exists at the passage of this act, so long as they comply with the laws of the United States, and with State, Territorial, and local regulations, not in conflict therewith, governing their possessory title, shall have the exclusive right of possession and enjoyment of all the surface included within the lines of their locations, and of all veins, lodes, and ledges throughout their entire depth, the top or apex of which lies inside of such surface lines, extended downward vertically, although such veins, lodes, or ledges, may so far depart from a perpendicular in their course downward as to extend outside the vertical side lines of said surface locations: *Provided,* That their right of possession to such outside parts of said veins or ledges shall be confined to such portions thereof as lie between vertical planes drawn downward as aforesaid, through the end lines of their locations, or locations in common, so continued in their own direction, that such planes will intersect such exterior parts of said veins or ledges: *And provided further,* That nothing in this section shall authorize the locator or possessor of a vein or lode, which extends in its downward course beyond the vertical lines of his claim, to enter upon the surface of a claim owned or possessed by another.

SEC. 4. *And be it further enacted,* That where a tunnel is run for the development of a vein or lode, or for discovery of mines, the owners of such tunnel shall have the right of possession of all veins or lodes, not previously known to exist, discovered in such tunnel, to the extent of five hundred feet on each side of the same; and locations on the line of such tunnel of veins or lodes not appearing on the surface, made by other parties after the commencement of the tunnel, and while the same is being prosecuted with reasonable diligence, shall be invalid.

SEC. 5. *And be it further enacted,* That the miners of each mining district may make rules and regulations, not in conflict with the laws of the United States, or with the laws of the State or Territory in which the district is situated, governing the location, manner of recording, amount of work necessary to hold possession of a mining claim, subject to the following requirements: The location must be distinctly marked on the ground, so that its boundaries can be readily traced. All records of mining claims hereafter made shall contain the name or names of the locators, the date of the location, and such description of the claim or claims, located by reference to some natural object or permanent monument, as will identify the claim. After the passage of this act, and until a patent shall have been issued, not less than twenty-five dollars' worth of labor shall be expended on improvements made upon each claim of two hundred feet during each year; but claimants in common, as defined in the second section of this act, may cause all the labor to be expended for improvements to be made upon any one claim, provided the aggregate amount equals twenty-five dollars a year to each claim of two hundred feet. And upon a failure to comply with this condition, the claim or mine upon which such failure occurred shall be open to relocation in the same manner as if no location of the same had ever been made: *Provided,* That the original locator has not resumed work upon the claim after such failure and before such location.

SEC. 6. *And be it further enacted,* That a patent shall be obtained in the following manner: any person, association, or corporation in possession of a mining claim or claims in common, who has complied with the mining regulations and the laws of the United States, may file in the local land office an application for a patent showing such compliance, together with a plat of the claim or claims in common; a copy of such plat, together with a notice of intention to apply for a patent, shall also be posted in a conspicuous place on the claim for the period of ninety days. The register of the land office, upon the filing of such application and plat, shall publish a notice that such application has been made for the period of ninety days, in a newspaper published nearest to said claim, and he shall also post such notice in his office for the same period. The claimant, at the time of filing his application, or at any time thereafter within ninety days of publication, shall file with the register a certificate of the United States surveyor general that one thousand dollars' worth of labor has been expended or improvements made upon the claim, by himself or grantors, that the plat is correct, with such further description by such reference to natural objects or permanent monuments as shall identify the claim and furnish an accurate description, to be incorporated in the patent. At the expiration of the ninety days of publication, the claimant shall file his affidavit, showing that the plat and notice have been posted in a conspicuous place on the claim during said period of publication. If no adverse claim shall have been filed at the expiration of the ninety days of publication, it shall be assumed that the applicant is entitled to a patent, and that no adverse claims exist, and thereafter no objection from third parties to the issuance of a patent shall be heard except it be shown that the applicant has failed to comply with this act.

SEC. 7. *And be it further enacted,* That where an adverse claim shall be filed during the period of publication, all proceedings, except the publication of notice and making and filing of the affidavit thereof, shall be stayed until the controversy shall have been settled or decided by a court of competent jurisdiction, or the adverse claim waived. It shall be the duty of the adverse claimant, within thirty days after filing his claim, to commence proceedings in a court of competent jurisdiction to determine the question of the right of possession, and prosecute the same with reasonable diligence to final judgment, and a failure so to do shall be a waiver of his adverse claim. After such judgment shall have been rendered, the party entitled to the possession of the claim, or any portion thereof, may file a certified copy of the judgment-roll with the register of the land office, together with the certificate of the surveyor general that the requisite amount of labor has been expended or improvements made thereon, and the description required in other cases, and shall pay to the receiver five dollars per acre for his claim, together with the proper fees, whereupon the whole proceedings and the judgment-roll shall be certified by the register to the Commissioner of the General Land Office, and a patent shall issue thereon for the claim, or such portion thereof as the applicant shall appear, from the decision of the court, to rightfully possess. If it shall appear from the decision of the court that several parties are entitled to separate and different portions of the claim, each party may pay for his portion of the claim, with the proper fees, and file the certificate and description by the surveyor general; whereupon the register shall certify the proceedings and judgment-roll to the Commissioner of the General Land Office as in the preceding case, and patents shall issue to the several parties according to their respective rights.

SEC. 8. *And be it further enacted,* That the description of vein or lode claims upon the surveyed lands shall designate the location of the claim with reference to the lines of the public surveys, but need not conform therewith; but where a patent shall be issued for a vein or lode claims upon surveyed lands, the surveyor general in extending the surveys shall adjust the same to the boundaries of such patented claim, according to the plat or description thereof, as in other cases of private claims.

SEC. 9. *And be it further enacted,* That sections one, two, three, four, and six of an act entitled "An act granting the right of way to ditch and canal owners over the public lands, and for other purposes," approved July twenty-six, eighteen hundred and sixty-six, are hereby repealed, but such repeal shall not affect existing rights, or prevent claimants now prosecuting their claims for patents from proceeding under said act: *Provided,* That this act shall be enforced as to such claims where it is not inconsistent with the act approved July twenty-six, eighteen hundred and sixty-six, aforesaid.

SEC. 10. *And be it further enacted,* That the "Act to amend an act granting the right of way to ditch and canal owners over the public lands, and for other purposes," approved July nine, eighteen hundred and seventy, shall be and remain in full force, except as to the proceedings to obtain a patent, which shall be similar to the proceedings prescribed by sections six and seven of this act for obtaining patents to vein or lode claims; but where said placer claims shall be upon surveyed lands, and conform to legal subdivisions, no further survey or plat shall be required, and joint entries shall be allowed for contiguous claims, as provided in said act: *Provided,* That proceedings now pending may be prosecuted to their final determination under existing laws; but the provisions of this act, when not in conflict with existing laws, shall apply to such cases.

SEC. 11. *And be it further enacted,* That where the same person, association, or corporation is in possession of a placer claim and also a vein or lode included within the boundaries thereof, application shall be made for a patent for the placer claim, with the statement that it includes such vein or lode, and in such case,(subject to the provisions of this act and the "Act to amend an act granting the right of way to ditch and canal owners over the public lands, and for other purposes," approved July 9, eighteen hundred and seventy,) a patent shall issue for the placer claim, including such vein or lode, upon the payment of five dollars per acre for such vein or lode claim, and one hundred feet of surface on each side thereof. The balance of the placer claim shall be paid for at the rate of two dollars and fifty cents per acre, and where a vein or lode, such as is described in the second section of this act, is known to exist within the boundaries of a placer claim, an application for a patent for such placer claim, which does not include an application for the vein or lode claim, shall be construed as a conclusive declaration that the claimant of the placer claim has no right of possession of the vein or lode claim; but where the existence of a vein or lode in a placer claim is not known, a patent for the placer claim shall convey all minerals within the boundaries thereof.

SEC. 12. *And be it further enacted,* That the Surveyor General of the United States may appoint in each land district containing mineral lands as many competent surveyors as shall apply for appointment to survey mining claims. The expenses of the survey of vein or lode claims and the subdivision of placer claims into smaller quantities than one hundred and sixty acres, together with the cost of publication of notices, shall be paid by the applicants, and they shall be at liberty to obtain the same at the

most reasonable rates, and they shall also be at liberty to employ any United States deputy surveyor to make the survey. The Commissioner of the General Land Office shall also have power to establish the maximum charges for surveys and publication of notices under this act; and in case of excessive charges for publication, he may designate any newspaper published in a land district where mines are situated for the publication of mining notices in such district, and fix the rates to be charged by such paper; and to the end that the Commissioner may be fully informed upon the subject, each applicant shall file with the register a sworn statement of all charges and fees paid by said applicant for publication and surveys, together with all fees and money paid the register and receiver of the land office, which statement shall be transmitted, with the other papers in the case, to the Commissioner of the General Land Office. The fees of the registers and receivers shall be the same as in other cases for similar services. But nothing in this act shall be construed to repeal, impair, or in any way affect the provisions of the "Act granting to A. Sutro the right of way and other privileges to aid in the construction of a draining and exploring tunnel to the Comstock lode in the State of Nevada," approved July twenty-five, eighteen hundred and sixty-six. *Provided*, That nothing in this act shall be construed to enlarge or affect the rights of either party in regard to any property in controversy at the time of the passage of the act entitled "An act granting the right of way to ditch and canal owners over the public lands, and for other purposes," approved July twenty-six, eighteen hundred and sixty-six, nor shall this affect any right acquired under said act.

It will be seen that this bill differs somewhat from the one which I had the honor to suggest in my last report. In some respects I regard it as superior to that, while in other respects there is still room for difference of opinion. At all events, I consider it the wisest and most beneficent measure that has ever been proposed in Congress on this subject; and if it becomes a law, I shall hope to see intelligent men in all the mining communities rally in its favor, give it a fair trial, and acknowledge its great value and importance. One thing which this bill unfortunately fails to do, is to legalize the location of timber and pasture tracts, mill-sites, etc., in connection with mines upon the public lands. This is a practice which has grown up without explicit authority of law in many of our interior districts. It is founded in necessity. The rigid enforcement of the law as it now stands, with regard to the timber on unsurveyed public lands, would almost put a stop to mining operations throughout several States and Territories; and there can be no doubt that, under proper restrictions, the protection of the law should be extended over this essential auxiliary part of mining industry, as much as over the immediate operations of extracting and reducing ore.

With regard to placer mines, the bill does nothing more than facilitate the acquirement of title from the United States, by simplifying the steps prescribed to the applicant for a patent, and by fixing the status of a quartz lode, discovered (as many a quartz lode is discovered) on a placer claim.

With regard to lode mines, three provisions of the greatest importance are established. In the first place, the title of the miner to the surface of his claim is distinctly declared. This, as I have argued in a former report, is really involved in the spirit and letter of the present law, which grants the land and fixes its price *by the acre;* but courts and juries have held both ways, and the General Land Office at Washington increased the doubt and confusion by patenting the same land over and over again to different parties. Before long we shall have, I trust, a clear and explicit law, which the jury-box cannot defy, and the bench and the bureau cannot manage to misunderstand.

At the same time, rights now existing are fully protected. The proposed law is unjust to no one, since it simply declares that hereafter certain regulations shall be observed which have heretofore been neglected. For a score of years the United States has permitted the miners on the public lands to prescribe their own rules of title and occupancy; and the result has been that, one after another,

the different State and territorial legislatures have been obliged to step in and overrule the selfish, lawless, short-sighted, absurd, and contradictory whims called district mining laws. Sometimes, as in the case of California, true principles have been established and substantial justice secured; sometimes, as in the case of Nevada, the attempt has been a failure. Everywhere the lawyers have thriven, and both miners and capitalists have bitterly suffered from this state of things. I trust, before it is too late, the matter will be taken in hand by supreme power, and will be dealt with in the light of universal experience.

The two other great features of the proposed law are equally concerned in the foregoing remarks. They are, the provision for proper record and definition of claims, and the provision for a certain amount of work annually to maintain the possessory title. It is amazing that this great reform has not been effected before now. The investment of capital in mining, without such security as is afforded by certain title, is a farce to outsiders, but a tragedy to the parties concerned. Particularly disastrous hitherto has been the effect of the reigning confusion and corruption upon mine-owners of moderate means. Rich men who owned rich mines could afford to defend themselves at law, and, in many cases, to fee the jury as well as the counsel; but poor men, willing to put their little money and their great industry and energy into the actual development of mines, were liable to become the victims of blackmailers and pirates.

The records of location should be made in such a way that the property can be found again. At present there is often nothing on the record but a date and a name. The essential point—identification of the lode—is dependent on the evidence of those who choose to "recognize," out of a thousand holes in the ground, the particular one which bears, or once bore, the name on the record.

Records should be kept in suitable books, in suitable buildings and under the care of responsible officers. At present, the titles to property worth millions of dollars are to be found in loose sheets, pocket-books, greasy, singed, torn and illegible old ledgers, or what not, kicking about miners' cabins, groceries, or bar-rooms. The recorders are not responsible, except to "Judge Lynch"; and he only interferes when his friends are wronged. For the Eastern or foreign capitalist there is too frequently neither security nor justice.

Again, and above all, the conditions on which a possessory claim is held ought not to be left entirely to the inhabitants of a mining district. The proposition is laughable when one considers what it involves. The individuals who claim something that belongs to the people of the United States are to fix the conditions on which the United States shall recognize their claim! No wonder that the local regulations of new districts are so drawn as to favor the worst kind of speculation—speculation without capital. Thousands of feet of mining claims are seized and held for sale, without being worked, and honest industry is thus strangled in its cradle.

I hold that the mineral deposits on the public lands are the property of all the people of this country; that the people, with wise liberality, have declared them free to the miner; and that any man who claims to own a mine which he has not bought and is not working, is interfering with that freedom of mining which the people have decreed.

Many districts are now languishing, with paralyzed industry, because all the ground has been covered with wild-cat locations, so that, if any one opens a mine, and by good luck and hard work makes it pay a

profit, some claimant is sure to start up, with documents and witnesses, to show that the present "Golconda" is the same as the ancient "Mary Ann," which he located once on a time and then abandoned, or which he bought from the original locator and abandoner, when the latter was "dead broke," and wanted to get to the States. This bill, if it becomes a law, will put an end to such mockery of mining within a year from its passage. It is not, indeed, to be expected that much actual development would be accomplished directly by requiring twenty-five dollars' worth of work every year on a claim; but it would no longer be possible for speculative but impecunious individuals to hold thousands of "feet" of mining property, without doing any work upon them. The door would be opened to honest industry, and slammed in the face of greedy idleness and fraud.

But it will be said that many of our mining districts have properly regulated these matters already, providing for due safety of titles, and requiring a certain amount of work to maintain the ownership of claims. This is true; and it is but right that all the districts shall be forced to do what these have done. The citizens of the United States or the capitalists of Europe, investing money in our mines, should be as much protected in one county or district as in another. What do they know of the differences of local regulations, which do not exist in any law-book or official record whatever, and which may be changed at any time by a mass-meeting of interested parties?

But it may be said, further, that no universal rule could be devised to cover the points named. This I doubt. If it is true at all, it is true with regard to the amount of work required to hold a claim. The amount which would seem reasonable in one district might, it is said, prove burdensome in another. I think the amount need be little more than nominal; and the alternative of paying a small sum in lieu of the work would relieve the case from possible hardship. It is not the amount of work or money; it is the vigorous requirement of *something*, that I consider necessary. Let the United States at least declare that a claim is forfeited by total abandonment for one year. This was declared, some two or three years ago, on grounds of common sense and public policy, by Judge Beatty, at Austin, Nevada; and that decision seemed to me profoundly wise and immensely important. But the Supreme Court of Nevada has since reversed it; and the rights of the United States and of enterprising industry are again at the mercy of blackmailers, quartz pirates, and wild-cat operators.

By Senator Stewart's bill, the mining lands would be put, so far as the nature of the case permits, in the same category as the agricultural lands of the public domain. The Government says to both farmer and miner: "Occupy and use, and you may possess." But the miner, in consideration of the peculiar risk and hardship of his undertaking, is the more favored of the two. No limit is set to the amount he may occupy, use, and either hold in perpetual possessory title, or acquired as the privileged purchaser at a fixed, low price. It is only demanded of him that he shall declare his claims distinctly, not take so much in any one place as to exclude others entirely, and not defeat the object of all the mining laws by abandoning his work while still claiming the exclusive privileges attendant upon bona-fide work, and upon nothing else. With the liberal grants made to him, he ought to be satisfied. If he is really a miner, he will be satisfied. If he is merely a broken-down speculator, who calls himself a miner, but whose real business is to locate, or buy, hold, "stock," and sell, paper mines, he will probably grumble, because under this law his profits may be curtailed.

Doubtless some minor points in the bill would be found to require modification to insure its smooth working. Those may be left to the indications of future experience. In its main features it is an eminently wise and salutary measure.* Senator Stewart has displayed both courage and judgment in its preparation, and has given new proof of intelligent, earnest devotion to the true interests of the mining industry.

* Since the above remarks were written this bill has failed, for want of time, in the Forty-first Congress, and has been introduced anew in the Forty-second. I trust it may receive prompt and favorable action. The evils which it is calculated to remove are the most pernicious of all which beset the business of mining west of the Missouri River.

CHAPTER XIX.

THE GEOGRAPHICAL DISTRIBUTION OF MINING DISTRICTS.

Professor W. P. Blake, in a note to his Catalogue of California Minerals, pointed out that the mining districts of the Pacific slope are arranged in parallel zones, following the prevailing direction of the mountain ranges. This interesting generalization has been more fully illustrated and connected with the geological history of the country by Mr. Clarence King, who sums up the observed phenomena as follows:

The Pacific coast ranges upon the west carry quicksilver, tin, and chromic iron The next belt is that of the Sierra Nevada and Oregon Cascades, which, upon their west slope, bear two zones, a foot-hill chain of copper mines, and a middle line of gold deposits. These gold veins and the resultant placer mines extend far into Alaska, characterized by the occurrence of gold in quartz, by a small amount of that metal which is entangled in iron sulphurets, and by occupying splits in the upturned metamorphic strata of the Jurassic age. Lying to the east of this zone, along the east base of the Sierras, and stretching southward into Mexico, is a chain of silver mines, containing comparatively little base metal, and frequently included in volcanic rocks. Through Middle Mexico, Arizona, Middle Nevada, and Central Idaho is another line of silver mines, mineralized with complicated association of the base metals, and more often occurring in older rocks. Through New Mexico, Utah, and Western Montana lies another zone of argentiferous galena lodes. To the east, again, the New Mexico, Colorado, Wyoming, and Montana gold belt is an extremely well-defined and continuous chain of deposits.

These seven longitudinal zones or chains of mineral deposits must not, in my opinion, be held to constitute a complete classification. The belts of the Coast Range and the west slope of the Sierra are well-defined, both geologically and topographically; but it is not so easy to separate into distinct groups the occurrences of gold and silver east of the Sierra. For instance, the gold of Eastern Oregon, Idaho, and Western Montana, together with such occurrences in Nevada as those of the Silver Peak and New Pass districts, and numerous instances of sporadic occurrence of particular ores of silver or argentiferous base metals, cannot be brought within the classification above given. Either more zones must be recognized, or a greater mineralogical variety must be acknowledged in those already laid down. The latter alternative is, I think, the more reasonable. According to the principles set forth in a discussion of mineral deposits in my last report, it appears evident that the agencies which affect the general constitution of geological formations are far wider in their operation than those which cause the formation of fissures; and that the causes influencing the filling of fissures are still more local in their peculiarities than those which form the fissures themselves. Thus, of the area covered by rocks of a given epoch, more or less uniform in lithological character, only a small portion may have been exposed to conditions allowing deposits of useful minerals, even when such deposits are contemporaneous, as in the case of coal. Still more limited is the field for the formation of fissures; but it must be freely confessed that in the case before us, the corrugation of half the continent into parallel mountain ranges offers good grounds for the expectation of vast longitudinal systems of fissures. When we come to consider the filling of these fissures, however, it is evident that the mineralogical character of the vein-material must vary, to some extent, as to the gangue, but to a still greater extent as to the nature of the ores. Even single mines, in the course of extensive exploitation, have produced ores differing as

widely as do those of the different zones enumerated by Mr. King. I am, in fact, strongly inclined to consider freedom from base metals, for instance, a peculiarity due in many cases to secondary processes, and not to be relied upon as characteristic for single veins even, to say nothing of whole groups, districts, and continental zones.

Nevertheless, the generalizations of Professor Blake and Mr. King on this subject are highly interesting and valuable. The criticism here made is not in opposition to their views so much as in qualification of a possible rash application on the part of the general public. The zonal parallelism does exist, though in a somewhat irregular way; and it is clearly referable, as these writers have shown, to the structural features of the country, the leading feature of which is the longitudinal trend of the mountain ranges.

Subordinate to this trend (or, more strictly, resulting from the same causes as produced it) appear the predominant longitudinal strike of the great outcrops of sedimentary rocks, the longitudinal axes of granite outbursts, and, finally, the longitudinal vents of lava overflows and the arrangement of volcanoes in similar lines. It is evident that in crossing the country from east to west we traverse a series of different formations, while, by following routes parallel with the main mountain ranges, we travel upon the continuous outcrops of the same general age.

Mr. King distinguishes in the history of the entire Cordillera two periods of disturbance which have been accompanied by the rending of mountain chains and the ejection of igneous rocks. Such periods would afford the conditions of solfataric action, thermal springs, and the generation of acid gases and metallic sublimates and solutions, and thus favor the formation of metalliferous deposits. The first of these periods, he says, culminated in the Jurassic, produced over the entire system a profound disturbance, and is, in all probability, the dating point of a large class of lodes. To the second, or tertiary period, he assigns the mineral veins which traverse the early volcanic rocks.

The expression "culminated in the Jurassic," merely refers, no doubt, to the fact that the cretaceous strata of California repose unconformably upon the upturned and metamorphosed Jurassic slates, having been themselves neither tilted nor highly metamorphosed. Perhaps it is well to remember, however, that the cretaceous is a weak point in the California series, at least, as determined by leading fossils; and perhaps the results of more complete stratigraphical surveys will indicate that there are gaps of no little significance, dynamically and chronologically, in this part of the geological record. At all events, the period of the folding of the Sierra Nevada (presumably that of the formation of many metalliferous deposits) was in some sense post-Jurassic, rather than Jurassic; and probably this is the meaning of Mr. King, who speaks of it in another passage as "late Jurassic."

The lodes which are referred to this period are of two types: first, those wholly inclosed in the granites, the outburst of which accompanied the upheaval of the earlier stratified group, or in the metamorphosed Jurassic and sub-Jurassic strata; secondly, those which occupy planes of stratification or jointure, thus following in general the dip and strike of the country rock, while they present in other respects the indications of fissure veins. The veins of the Reese River granite are examples of the first type; many gold veins of California, the Humboldt mines, etc., are given as illustrations of the second. The White Pine district, the mineral deposits of which are said to be inclosed conformably between strata of Devonian limestone, is declared to be "a prominent example of the groups comprised wholly within the ancient rocks."

We have hitherto supposed the strata immediately overlying the argentiferous limestone at White Pine to be deep-water Carboniferous; but their Devonian character seems to be demonstrated in the geological chapter on that subject by Mr. Arnold Hague, quoted elsewhere in this volume. More practically important is the assignment of these deposits to the earlier period of geological disturbance. Mr. King appears here to include in one group *all* the White Pine deposits, the "Base Range" as well as "Treasury Hill;" yet the striking distinction in mineralogical character is worthy of regard. The deposits of Treasure Hill are notably free from base metals; and it seems to me that in their present form they must be due to a secondary action, which has concentrated and recombined the metallic elements of older deposits. It should be added, however, that although the chlorides of Treasure Hill are as pure as those of Lander Hill, they do not appear, like the latter, to yield in depth to such silver ores as characterize the fissure-veins of Reese River district—ruby silver, for instance. Nor are they fissure-veins, so far as we can now decide.

To the Tertiary period of orographical disturbance are referred the volcanic overflows and the veins wholly or partly inclosed in volcanic rocks. Uuder this head Mr. King classes many important veins of Mexico, several of those which border the Colorado River, in the United States, and, in general, that zone which lies along the eastern base of the Sierra Nevada. The Comstock lode is adduced as the most prominent example of this type, and the Owyhee district in Idaho is also referred to it, because, although in granite, it presents a series of volcanic dikes which appear to prove, by the manner of their intersections with the quartz lodes, that the latter are of Tertiary origin. It will be seen that although the extent and number of the deposits of this class are inferior to those of the earlier period, they include some of the most brilliant instances in the history of mining. As Mr. King, however, points out, many of the veins which are wholly inclosed in the older rocks may nevertheless be due to this later period of disturbance. Nor does he ignore the bearing of this thought on his determination of the earlier period as Jurassic. He confesses that in more recent strata, formed from debris of Jurassic roeks, ore-bearing pebbles have not been found; but he regards this fact as a piece of negative evidence merely.

The distribution of mineral deposits east of the Rocky Mountains follows somewhat different laws. Here we have but one longitudinal range—that of the Alleghanies, which is accompanied by a gold-bearing zone of irregular extent and value. In the Southern States the strata flanking this range present a remarkable variety of mineral deposits. On the eastern slope of the Rocky Mountains, again, occurs what may perhaps be denominated a zone or longitudinal series of coal-fields. But between these mountain boundaries the geological formations of the country cluster, as it were, around centers or basins. We have such a group in Michigan, another in the Middle States, and a third in the Southwest.

The deposits of the different metals, ores, and useful minerals, in the country east of the Rocky Mountains, vary widely in age. The ores of gold, copper, and iron, in the pre-Silurian schists of the South; the galena and cobalt ores of the Southwest, and the copper ores of Lake Superior, in the lower Silurian rocks; the argillaceous iron ores of New York, and other States west of New York, in the Upper Silurian, and the salines of the same group; the bitumen, salt, coal and iron ores of the Sub-carboniferous; the coal and iron of the Carboniferous; the coal, copper, and barytes of the Triassic; the lignites of the Cre-

taceous, and the fossil phosphates of the Tertiary period, are instances which may serve to show how great is this variety. It is not within the province of this report to discuss the mineral deposits of the Mississippi Basin, the Appalachian Chain, or the Atlantic Coast. I shall content myself with brief mention of two points. The first is the greater relative age of the metalliferous deposits as compared with those of the inland basin and the Pacific slope. On this side the period of greatest activity in such formations was over before it began in the West. The great gold and silver deposits beyond the Rocky Mountains appear to be post-Devonian, post-Jurassic, and even Tertiary in their origin. The vast volcanic activity which affected so wide an area in California, Oregon, Washington, Idaho, and Nevada, is not represented in the East.

The other point is the peculiar relative position of our coal and iron deposits. This was eloquently described by Mr. Abram Hewitt, United States Commissioner to the Paris Exposition, in his admirable review of the iron and steel industry of the world. I cannot do better than quote his forcible words:

> The position of the Coal-Measures of the United States suggests the idea of a gigantic bowl filled with treasure, the outer rim of which skirts along the Atlantic to the Gulf of Mexico, and thence, returning by the plains which lie at the eastern base of the Rocky Mountains, passes by the great lakes to the place of beginning, on the borders of Pennsylvania and New York. The rim of the basin is filled with exhaustless stores of iron ore of every variety, and of the best quality. In seeking the natural channels of water communication, whether on the north, east, south, or west, the coal must cut this metalliferous rim; and, in its turn, the iron ore may be carried back to the coal, to be used in conjunction with the carboniferous ores, which are quite as abundant in the United States as they are in England, but hitherto have been left unwrought, in consequence of the cheaper rate of procuring the richer ores from the rim of the basin. Along the Atlantic slope, in the highland range, from the borders of the Hudson River to the State of Georgia, a distance of one thousand miles, is found the great magnetic range, traversing seven entire States in its length and course. Parallel with this, in the great limestone valley which lies along the margin of the coal-field, are the brown hematites, in such quantities at some points, especially in Virginia, Tennessee, and Alabama, as to fairly stagger the imagination. And, finally, in the coal basin is a stratum of red fossiliferous ore, beginning in a comparatively thin seam in the State of New York, and terminating in the State of Alabama in a bed 15 feet in thickness, over which the horseman may ride for more than one hundred miles. Beneath this bed, but still above water-level, are to be found the coal-seams, exposed upon mountain sides, whose flanks are covered with magnificent timber, available either for mining purposes or the manufacture of charcoal iron. Passing westward, in Arkansas and Missouri, is reached that wonderful range of red oxide of iron, which, in mountains rising hundreds of feet above the surface, or in beds beneath the soil, culminates at Lake Superior in deposits of ore which excite the wonder of all beholders; and returning thence to the Atlantic slope, in the Adirondacks of New York, is a vast, undeveloped region, watered by rivers whose beds are of iron, and traversed by mountains whose foundations are laid upon the same material. In and among the coal-beds themselves are found scattered deposits of hematite and fossiliferous ores, which, by their proximity to the coal, have inaugurated the iron industry of our day. Upon these vast treasures the world may draw for its supply for centuries to come; and with these the inquirer may rest contented, without further question—for all the coal of the rest of the world might be deposited within this iron rim, and its square miles would not occupy one-quarter of the coal area of the United States.

This vivid description rests upon a geographical rather than a geological grouping. But it is none the less intimately connected with the underlying geological facts. Its strongest application is, however, economical. If any material thing may stand as the type of force, it is coal, the deposits of which may well be called vast storehouses of power—the product of solar activity through uncounted years—laid up for the use of man; and iron, on the other hand, may symbolize the inert, dead matter, awaiting the touch of power to wake it into efficient life. These are prime elements in our universe of industry. Take them away and our

present civilization is annihilated. Put them together in the hand of an intelligent and mighty nation, and that nation could recall the world from the chaos of barbarism. But they need each other, and it is in the wonderful combination of both, as well as the exhaustless abundance of each, that America finds sure promise of enduring power.

Thus East and West bear witness of our great inheritance of natural wealth. Every period of geological change has been laid under contribution to endow with rich legacies some portion of our land. Our territory epitomizes the processes of all time, and their useful results to man. Divided, yet in a stronger sense united, by mountain chains and mighty rivers, our diversified mineral resources may figuratively represent, as I firmly believe they will literally help to secure and maintain our characteristic national life, a vast community of communities, incapable alike of dissolution and of centralization; one, by mutual needs and affections, as the continent is one; many, by multiform industries and forms of life, as the members of the continent are many.

CHAPTER XX.

THE ORIGIN OF GOLD NUGGETS AND GOLD DUST.

The following article, from the pen of Mr. Andrew Murray, F. L. S., which appeared in 1870 in the London Scientific Opinion, corroborates forcibly the suggestions and opinions advanced in my last report (chapter lxi, page 449) upon the same subject. It is to be hoped that a hypothesis so highly probable as that of the solution, precipitation, and aggregation of gold in placers may be subjected to the test of careful experiments and comparisons:

The origin of gold nuggets and gold dust is not so simple or clear as at first sight it appears to be. The natural explanation of the production of gold dust is, that it is the golden portion of the *débris* of rocks, which have originally had gold disseminated through them. As the wear and tear of ages has crumbled into dust mountains so composed, part of the dust becomes sand, or quartz, or whatever else the basis of the rock may be, and the other part is the liberated gold, from which the quartz has been rubbed away; and if we accept this as the explanation of the production of gold dust, the same hypothesis should explain that of gold nuggets, which are found associated with it. But there are various circumstances which it is difficult to reconcile with this theory. One of these is the occurrence in the drift of nuggets of a larger size and less intermixed with foreign substances than have yet been discovered in any quartz reef; as most people are aware, the gold in reefs is usually disseminated in particles and strings through the quartz-veins or rock, instead of lying in pockets or masses. Another still more remarkable fact, applicable both to gold dust and gold nuggets, is that alluvial gold is generally of a higher standard than that obtained from the reefs. It is needless to say that if it is merely the gold washed or crumbled out of these reefs, it ought to be of identically the same standard and quality. Another objection to the dust being merely the degraded particles released from the rock, is the size of the particles—not nuggets, but particles of dust. Gold being so much softer than quartz, its particles, after being subjected to the same degree of attrition, ought to be vastly smaller. Although of greater toughness than quartz, and possessed of ductility and tenacity, which quartz wholly wants, it is very soft, and, under the influence of the attrition from running water and its accompaniments, ought to be pounded and torn into the minutest fragments; but this is not so. There is, moreover, a marked difference in the appearance of the gold dust from different drifts in different countries. In some it is like dust or sand, in others it is like scales. If subjected to the same influences in all, there seems no reason why the same shape should not obtain in all cases.

These peculiarities would suggest that some other influence than mere degradation of gold-charged rocks has been the agent in producing gold dust; but in any and every view, we think it cannot be disputed that degradation must have had some share in the work. It is plain that if a gold-charged rock is reduced to gravel, sand, or powder, particles of gold, of some size or other, or gold in some shape or other, must form part of the *débris*. These gold remnants should be found in greater quantity, and in greater size, the nearer they lie to the source from which they were drawn, and this we believe also to be the case. The general similarity between gold-producing districts, by which a Californian miner could detect a likely spot for gold in Australia or Kildonan, probably depends rather on the character of the mountains out of which the gold has come than on the mode of production of the manufactured dust, if we may call it so. We imagine that the truth will be found to be that the result is referable to two causes, only one of which may in some cases have been present, in others, both. The first, the ordinary process of degradation and grinding the rocks to fragments; the other, as suggested by Mr. Selwyn, the government geologist of Victoria, that gold has also been taken up in solution by the water permeating the gold-bearing rocks, and that in passing through the drift, in which minute particles of gold lay, it has, from some cause, become decomposed, and the gold held in solution been precipitated and deposited around the most congenial *nuclei* presented to it, which would undoubtedly generally be the particles or pieces of reef-gold, or any other metallic substances for which it had an affinity.

We find an interesting paper on this subject in the Transactions of the Royal Society of Victoria, 1867, by Mr. C. Wilkinson, in which he mentions some facts bearing on the subject. It appears that Mr. Daintree, formerly of the geological survey of Victoria, had on one occasion prepared for photographic uses a solution of chloride of gold,

leaving in it a small piece of metallic gold undissolved. Accidentally, some extraneous substance, supposed to be a piece of cork, had fallen into the solution, decomposing it, and causing the gold to precipitate, which made a deposit in the metallic state, as in the electro-plating process, around the small piece of undissolved gold, increasing it in size to two or three times its original dimensions. Considering this accidental experiment of Mr. Daintree's as in some measure supporting Mr. Selwyn's theory, Mr. Wilkinson followed it up by a few simple experiments in the same direction, which he details in his paper. In his experiments a small chip of wood was generally used as the decomposing agent. In one instance he used a piece of leather. All through the wood and leather gold was disseminated in fine particles, and, when cut through, the characteristic metallic luster was highly reflected. From various experiments it would appear that organic matter is the necessary chemical agent for decomposing a solution of the chloride of gold in order to precipitate the gold as a coherent coating around a nucleus; and that, so far as Mr. Wilkinson had yet tried, iron, copper, and arsenical pyrites, galena, antimony, molybdenite, blende, wolfram, and metallic gold constitute essentially favorable *nuclei* to determine this chemical reaction. It is to be observed, too, that organic substances, such as fragments of wood, roots of trees, etc., occur abundantly in the gold drifts of Australia. If water holding gold in solution circulates through the rocks and drifts, all the conditions necessary for the production of gold dust and nuggets by deposit are present. Does the water so circulating now hold gold in solution?

One would think it would not be difficult for a chemist in Australia or California to determine the fact by direct experiment, but it does not appear that it has ever been tried. Mr. C. Wilkinson, however, quotes facts which lend probability to the view that when the trial is made the question will be solved in the affirmative. In testing a solid mass of iron pyrites Mr. Daintree found gold throughout. The mass retained the structure of a tree stem, in which the organic structure was replaced by pyrites. It had been taken from the Ballarat drift, and the same experiment was repeated by Mr. Newbury, the geological survey analyst, on another stem taken from the same drift, with a like result. Gold in such deposits assumes a mammillary form, which appears analogous to that presented by the surface of nuggets—a point of some importance, for, in the first place, it is a question whether a mammillary surface is the kind of surface that would be produced by abrasion and attrition; and, in the next place, abrasion or attrition can certainly have nothing to do with its appearance in these golden petrifactions. We cannot avoid attaching the greatest importance in relation to the question to the presence of gold in pyrites that has been formed in wood imbedded in auriferous drifts. The gold *must* have been in solution when so deposited, and everything will then depend on the age of the so petrified wood. If contemporaneous with the drift, the question is answered. Another fact to the same effect is, that sometimes gold incloses a nucleus of brown iron, etc. This is obviously quite inconsistent with such pieces of gold having been abraded, as they are out of crumbling rocks; such nucleated pieces of gold are never found in reefs. It is the old puzzle of a reel in a bottle. In relation to this we may remark that we believe that nuggets have never been found in the gold-fields of Brazil. We have the authority of Mr. Harding, a gentleman well known for his great practical knowledge of gold mines and mining in that country, that he never met with nor heard of a nugget, properly so called, in all his many years' experience in the gold district of Brazil; but, on the other hand, it is there almost invariably found in veins in connection with or in the vicinity of some other metal, generally iron. In what is probably the most prolific mine of gold that has ever been known in the whole world, that of San Juan del Rey, (the value of which was not long since so seriously depreciated by the accidental destruction by fire of the wooden ladders, supports, and machinery,) the gold is found in a matrix of porous iron or agglutinated iron sand, called Jacotinga, which consists of a bed or vein not a foot in width, but so incredibly rich that on one occasion, when our informant was on a visit to the manager, there was brought in on an assiette, as a sort of dessert for the eyes after dinner, a lump of gold ore that had been extracted that day from the mine. It was about the size of a large fowl; not so big as a turkey, but bigger than a duck. It was a mass of Jacotinga iron, with gold all mingled and streaked through it. The gold, when afterward extracted, was found to amount to 30 pounds weight. On the previous day the amount of gold obtained from the Jacotinga had been 67 pounds, and on the day following 130 pounds, equal in value to about £8,000. We only mention it as a corroborative instance of the concurrent presence of gold and iron. Lastly, as pointed out by Mr. Wilkinson, it must be admitted that the fact that gold may be greatly purified by dissolving and reprecipitating it, is very suggestive of the generally higher standard of alluvial over reef gold being due to a similar cause

CHAPTER XXI.

THE BULLION PRODUCT.

The difficulty of ascertaining the production of gold and silver in this country is peculiarly great, by reason of the lack of organized means and the extent of the field through which our mines are scattered, as well as the nature of the industry itself, and the motives which influence the minds of those engaged in it to withhold from publication the full and true account of its results.

When I entered upon my duties as commissioner of mining statistics I gave this subject careful attention. My predecessor had presented estimates of bullion production, involving confessedly a large excess over the amount actually accounted for by the statistics of either express shipments, exports and coinage, or the bullion tax. He had recommended the collection of accurate and comprehensive returns through resident agents in the mining States and Territories—a system which was not practicable then, and has not been practicable since, on account of the limited funds appropriated for the work. So far, however, as circumstances would permit, I have pursued the policy of obtaining from experts in different regions estimates of such portions of the production as were not covered by detailed and accurate returns, using, moreover, my own judgment, based upon extensive annual journeys of observation, in the modification of such estimates as I had reason to believe were without sufficient foundation. The elements entering into conclusions of this character are: the reports of production from single leading mines; the express shipments of bullion; the rates charged by express companies; the number of miners, white and Chinese, and the respective wages paid; the number and capacity of stamps running; the cost of mining and reduction, etc. The aggregate product of bullion thus obtained is of course merely a rude estimate. It has never been put forward as anything else, and I do not feel called upon to defend its accuracy.

As I committed the error of including my estimate of bullion in the introduction to my report of last year, which was set up and stereotyped several months before the last pages went to press, it does not agree with later estimates in the different chapters of the report. Thus Oregon and Washington are credited on page 7 with a product of $4,000,000; on page 205, their aggregate production is stated as $3,000,000. Again, Montana is credited on page 7 with $12,000,000; on page 317 this is corrected, and the cause of the error explained, while the product is cut down to $9,000,000, on the strength of later reports as to the effect of drought on the gulch mines.*

But all the excess of gold attributed in the introduction to my last report to Oregon, and more than a million of the excess in the earlier estimate for Montana, (made in September, and based on the product of the fiscal year, without foresight of the excessive drought,) belonged properly to California. For I have never been able to get direct returns from all the mining districts of that State. The attempts which have been made are detailed in a former report; and it is the experience of all who

* I declared (p. 317) that $9,000,000 seemed to me too small a figure. The surveyor general's official estimate for the year was $10,000,000. My investigations this year, however, corroborate the correspondent who sent me the smaller estimate.

have undertaken to obtain such information in California that the task is well-nigh an impossibility. The San Francisco press, noted for its enterprise in statistical matters, contents itself with presenting annually the receipts of the express companies, the coinage at the mint, and the shipment of bars, data which give, within a certain percentage, the amount of the precious metals received at San Francisco. I have usually deducted from this aggregate the amounts due to Arizona, Nevada, Oregon, Washington, Idaho, and Montana, (not the whole product of all these States and Territories, but the portion sent to San Francisco,) and credited California with the rest. That this gives a fairer result than could be obtained by a direct inquiry may be seen from the ill success of the assistant marshals under the Census Bureau, the aggregate of whose returns of gold product in California, submitted to me in January, 1871, was between $8,000,000 and $9,000,000 for the whole State, and for the whole of the year ending June 1, 1870.

Following the plan above mentioned, I obtained for California the sum of $20,000,000, which agreed with my own observations of the depressed condition of the placer mines in many districts, and of certain other causes operating to produce local diminution of product. But this estimate was too low, because the amounts subtracted for Oregon and Montana were too high. The table given in my introductory letter last year is therefore to be rejected, as contradicted by the later evidence of the body of the report. I regret that attention was not more distinctly called to this fact in the appendix; but the truth is, that I did not keep in mind, as the voluminous work passed through the press, the whole of those parts which had gone beyond my reach; and the corrections made upon later evidence, in the chapters on Oregon, Montana, etc., were introduced without proper regard to their bearing upon what had been said hundreds of pages before.

If the estimate of bullion product for 1869 had been the last instead of the first thing in the report, it would have been conformed to these corrections. I can now only introduce the corrected table as my estimate for 1869:

California	$22,500,000
Nevada	14,000,000
Oregon and Washington	3,000,000
Idaho	7,000,000
Montana	9,000,000
Colorado and Wyoming	4,000,000
New Mexico	500,000
Arizona	1,000,000
All other sources	500,000
Total	61,500,000

The term "all other sources," which I have retained from the reports of my predecessor, does not very definitely show the meaning intended. This item includes the product of precious metals east of the Rocky Mountains, and also a small margin of compensation for underestimates upon single States or Territories.

The following is my estimate of the product of 1870:

California	$25,000,000
Montana	9,100,000
Idaho	6,000,000
Utah	1,300,000

Arizona	$800,000
Oregon and Washington	3,000,000
Colorado	3,675,000
Wyoming	100,000
Nevada	16,000,000
New Mexico	500,000
Other sources	525,000
Total	66,000,000

All the above items, except the first and last, are based upon direct and positive evidence, collected, sifted, and weighed with my best care and judgment. The product of California is obtained, as usual, by a series of deductions from the receipts of bullion at San Francisco. I have no better way, since it would be absurd to accept the results of direct inquiries in that State as covering the whole product. Such a course would put California down to about $9,000,000, which I should consider outrageously unjust. I believe that my estimate is nearly correct.

These results are obtained without reference to the statistics of coinage and export, and largely exceed the aggregate of those two items. According to some writers, however, the total annual product of bullion may be closely approximated by merely adding together the coinage of domestic gold and silver at the mint and its branches, (or the deposits for coinage less the amount returned to depositors in bars,) and the exports of bullion of native production. I do not agree with this view, and I shall give at some length my reasons for dissent. These may be classed under two general heads: first, the imperfection of the data afforded for an accurate calculation of either coinage or exportation; and second, the inadequacy of the method itself. I need scarcely add, that if I had not become sincerely convinced on these points, I should certainly have saved myself much independent labor and research, and adopted the comparatively very cheap and easy system of studying the mining industry and its results by means of mint and custom-house reports.

I will first give some tables, constructed on the method referred to, and show their deficiencies.

The following figures for the domestic deposits of gold and silver for coinage are obtained by taking from table C (now B) the reports of the Director of the Mint, the deposits at the Philadelphia and San Francisco mints, and adding the amount of fine bars received at the Mint in Philadelphia, as shown in table A. It would be easy to show that this does not give an exact result, since no account is taken of the fine bars produced at Philadelphia, nor of the foreign origin of a portion of the fine bars deposited at San Francisco, or sent from New York to Philadelphia, nor of the native origin of a portion of the jewelers' bullion; but it is the best that can be done with the Mint reports as they are at present made out. The amount of silver bars produced at San Francisco is deducted from the reported deposits at that place, and for 1866 and 1870, the amount of fine silver bars sent to Philadelphia evidently including a large portion of foreign origin, I have taken instead the amount produced at New York, as involving less error.

The figures of the exports of bullion are compiled from the reports of the Bureau of Statistics of the Treasury Department:

Table of domestic coinage deposits and exports of domestic bullion for the fiscal years ending June 30, 1866, 1867, 1868, 1869, *and* 1870.

	1866.	1867.	1868.	1869.	1870.
Deposits, gold	$27, 286, 596	$27, 327, 508	$18, 292, 793	$19, 894, 792	$19, 182, 649*
Exports, gold	20, 731, 473	13, 867, 641	23, 984, 021	13, 584, 407	15, 814, 108
Total, gold	48, 018, 069	41, 195, 149	42, 276, 814	33, 479, 199	34, 996, 757
Deposits, silver	450, 939	890, 733	938, 666	798, 331	1, 320, 615†
Exports, silver	10, 832, 849	15, 853, 530	12, 865, 237	13, 573, 427	11, 784, 864
Total, silver	11, 283, 788	16, 744, 263	13, 803, 903	14, 371, 758	13, 105, 479
Total deposits, gold and silver	27, 737, 535	28, 218, 241	19, 231, 459	20, 693, 123	20, 503, 264
Total exports, gold and silver	31, 564, 322	29, 721, 171	36, 849, 258	27, 157, 834	27, 598, 972
Grand total, gold and silver deposits and exports	59, 301, 857	57, 939, 412	56, 080, 717	47, 850, 957	48, 102, 236

* Including deposits at Carson City, (less $66, fine bars produced there.) A deduction has been made of $1,274,458, Japanese gold, received as domestic at the San Francisco mint.

† The sum of domestic deposits at Philadelphia, San Francisco, Carson City, and the fine bars from New York. The table on page 43 of the Director's report for 1870 erroneously omits Carson City. I am forced to assume that the $707,400, silver bars of the New York assay office, were sent to Philadelphia for coinage, as there is no means of separating the small amount returned to depositors.

The Alta California of February 17, 1871, makes the following observations:

The true mode of getting at the production has been pointed out, and, for the last six years, we have annually given the production of this coast as received at San Francisco. The method is the same as that adopted in regard to the cotton crop and other great staples. It is by ascertaining how much cotton is exported, how much burned and destroyed, and how much is taken by the manufacturers. The result is taken by the world at large as the cotton crop. It would not shake confidence in the figures if some statistical neophyte were to object that some cotton is used to stuff into people's ears when they have the earache, and is therefore not thus accounted for. So with gold and silver. The world knows that raw bullion is of no use to the producer; it must be turned into coin, or sold as bars. In either case the whole quantity is practically accounted for—that is, all the gold and silver which affects the markets of the world comes to light in this manner. The production of the metals in the United States has been, for five years, as expressed in the following table, showing the net amount of domestic gold and silver deposited at mint and turned into coin, and the amount of bars of gold and silver exported by official return:

Year.	Deposited at mint.		Domestic bars exported.	
	Gold.	Silver.	Gold.	Silver.
1866	$27, 095, 547 93	$80, 509 74	$20, 731, 473	$10, 832, 849
1867	27, 327, 502 00	474, 645 08	13, 867, 641	15, 853, 530
1868	16, 712, 225 33	649, 388 66	23, 984, 021	12, 865, 147
1869	19, 402, 064 30	300, 870 66	13, 584, 407	13, 573, 427
1870	18, 927, 669 00	644, 803 17	15, 814, 108	11, 784, 864

Year.	Production.		Total.
	Gold.	Silver.	Gold and silver.
1866	$47, 827, 020 93	$10, 913, 358 74	$58, 740, 379 67
1867	41, 195, 143 00	16, 328, 175 08	57, 523, 318 08
1868	40, 696, 246 33	13, 514, 535 66	54, 210, 781 99
1869	32, 986, 451 30	13, 874, 297 66	46, 860, 748 96
1870	34, 741, 777 00	12, 428, 667 17	47, 170, 444 17
Average	39, 489, 323 71	13, 411, 806 86	52, 901, 134 57

There are two leading disturbing elements in this manner of getting at the production of a single year; one is the quantity of imported gold turned into refined bars and deposited at mint, and there received as domestic gold. In the year 1870, $1,274,458 Japanese gold was so turned in, but has been deducted in the table. The other element is the irregularity of the export of bars. If all the bars produced in one year were exported, and only those, each year's return would give each year's product. This, however, is not the case; as thus, in 1866, there commenced at the New York assay office an operation of lending public money to certain parties on unparted bars, which caused the retention of those bars in the assay office, and their omission in the report for coinage. The exports of gold bars for the year were, therefore, by so much less, thus making the production appear less. That operation was continued until the spring of 1870, when Mr. Boutwell broke it up, and the bars were exported, thus apparently swelling the production of 1870. It is also the case that bullion remains in the hands of the bullion dealers at the end of the fiscal year, to be exported in the next. But the average of five years covers all those disturbing causes, and gives a production of $39,489,323 71 of gold, and of $52,901,134 57 gold and silver; and there has been a gradual annual decline in it. It will be observed that the year 1867, that in which the apparent production was lessened by the retention of bars in the New York assay officer the amount is given at $41,013,997 gold. In the report of Mr. Browne, mining commis, sioner for that year, we find (page 260) the return of the Internal Revenue Commissionefor that calendar year, giving the gold product in coin value, paid tax, at $45,161,050. The difference of about $4,000,000 is that of bars retained at the New York assay office. The total in the table of gold and silver is $57,523,318 08; that in the revenue return is $58,175,047—a difference of $651,729. The Secretary of the Treasury estimated for that year in his report (page 3) the production at $75,000,000—a difference of $16,824,953. The mode we have adopted, it will be seen, covers all the gold product that comes practically into the service of the public, and the results may be safely taken as the actual product of the precious metals.

I shall have occasion presently to consider the argument involved in these remarks; but I wish first to call attention to the table of deposits of gold and silver, which differs greatly, especially in the item of silver, from the one I have just given. The writer in the Alta seems wholly unconscious of any inaccuracy, and declares the figures in question to be the net amounts of gold and silver deposited at the Mint and turned into coin. In reality, they do not appear in the Director's reports, but are obtained by deducting the total deposits of United States coin, jewelers' bars, foreign coin, and foreign bullion from the total coinage (excluding bars) of the Mint and branches. This is assuming that all the deposits under the four above-mentioned heads are turned into coin, or, in other words, that all the fine bars produced at the mints and assay offices are from domestic bullion only. This assumption is, *a priori*, unreasonable; and I have, by inspection of the official (unpublished) records of the Mint, proved it to be false in fact. The deposits at the New York assay office, for instance, are entered in a descriptive list, and opposite to each of them is a memorandum of the manner of payment, whether in bars, gold, or silver coin. Unfortunately this distinction is carried no further; and the consolidated returns contain, therefore, the domestic and other deposits in separate aggregates, and the coinage and bars in separate aggregates; but there is no way of determining how much of each class of deposits is turned into coin and how much into fine bars, except by laboriously examining in detail the history of each separate deposit. This I have done only far enough to be satisfied that the device of deducting the total jewelers, and foreign deposits, etc., from the total coinage, to obtain the domestic bullion coined, is wholly untrustworthy. The method I have followed in the first table given is, in my opinion, superior in accuracy; but no possible manipulation of the Director's reports can give correct results on these points, so long as those reports continue to be constructed as at present.

But these tables are inconvenient for purposes of comparison, because they refer to the fiscal instead of the calendar year. I have received, however, from the different mints and assay offices figures

relating to calendar years, which I will give here, both for their present application, and because I know from personal experience that this recasting of the ordinary inconvenient term will be welcome to many statisticians. Fortunately, a system of quarterly reports has now been introduced, so that in future the mint tables can be much more readily analyzed.

For the following reports I am indebted to Hon. James Pollock, Director of the Mint at Philadelphia; Mr. Henry F. Rice, superintendent of the branch mint at Carson City; Mr. Jacob F. L. Schirmer, assayer of the branch mint at Denver; Mr. Calvin J. Cowles, assayer of the branch mint at Charlotte; and Messrs. Edelmann, Conant, and Floyd, of the New York assay office. Inquiries addressed to the superintendent of the San Francisco branch mint were not answered, and I have taken the figures referring to that institution from the Commercial Herald and Alta California, of San Francisco:

MINT OF THE UNITED STATES AT PHILADELPHIA.

	Gold.	Silver.
Calendar year 1867:		
United States bullion	$4,636,334 06	$224,313 08
Jewelers' bars, etc	153,471 03	27,248 48
Foreign bullion	361,126 83	13,485 53
Total deposits	5,150,931 92	265,047 09
Less fine bars	93,999 39	4,424 14
Amount of coinage	5,056,932 53	260,622 95
Calendar year 1868:		
United States bullion	1,684,655 44	380,683,25
Jewelers' bars, etc	166,532 79	30,928 27
Foreign bullion	416,220 13	22,161 81
Total deposits	2,267,408 36	433,773 33
Less fine bars	104,901 89	4,799 17
Amount of coinage	2,162,506 47	428,974 16
Calendar year 1869:		
United States bullion	3,040,884 21	1,062,847 26
Jewelers' bars, etc	164,980 66	38,022 25
Foreign bullion	609,547 43	14,777 00
Total deposits	3,815,412 30	1,115,646 51
Less fine bars	164,630 15	194,641 64
Amount of coinage	3,650,782 15	921,004 87
Calendar year 1870:		
United States bullion	2,911,043 78	1,023,044.01
Jewelers' bars, etc	166,886 00	18,060 52
Foreign bullion	421,849 07	37,172 13
Total deposits	3,499,778 85	1,078,276 66
Less fine bars	125,200 42	203,267 38
Amount of coinage	3,374,578 43	875,009 28

SAN FRANCISCO BRANCH MINT.

The coinage at the branch mint in this city for the year 1870 compares with that in 1867, 1868, and 1869, as follows:

Month.	1867.	1868.	1869.	1870.
January	$124,000	$97,000	$467,000	$1,660,000
February	1,022,000	640,000	185,000	985,000
March	978,535	575,000	743,000	2,155,000
April	1,895,000	710,000	1,579,000	1,330,000
May	2,505,000	714,000	985,000	2,023,000
June	1,420,000	922,000	1,348,000	2,106,000
July	1,152,000	2,355,000	1,040,000	120,000
August	2,380,000	1,465,000	689,500	2,370,000
September	1,989,000	2,455,000	2,550,000	2,030,000
October	2,361,000	2,415,000	1,669,300	1,875,000
November	2,260,000	2,595,000	1,648,000	1,965,000
December	1,284,000	2,442,000	1,459,750	1,676,000
Totals	19,370,535	17,365,000	14,363,550	20,355,000

The amount of coin turned out by the branch mint in this city during the year 1870 has never been exceeded but twice, viz: in 1855 and 1856. In the former of those years the coinage amounted to $21,121,752, and in 1856 to $28,516,147. The coinage for 1870 is $5,991,450 in excess of that for 1869. When the new building, now in process of erection, shall have been finished, greatly enlarged and needed facilities will be available, and the work can be prosecuted with far more dispatch, regularity, and less waste. The entire coinage of the branch mint since its organization, in 1854, has been $291,877,163.

The deposits at the branch mint since 1866 are given by a San Francisco paper as follows:

1866	$17,617,076
1867	19,265,376
1868	17,367,000
1869	15,502,457
1870	20,492,055

According to another, slightly different account, the deposits of 1870 amounted to $20,473,711 90, of which $7,644,594 48 was received as native bullion at the mint, and $12,829,117 42 was deposited first at the San Francisco Assaying and Refining Works, and afterward sent to the mint as fine bars. Up to the close of July the mint refined its own gold deposits; since that time it has sent (up to January 1, 1871) to the private refinery alluded to, $3,614,443 21, and received it again, with $5,431,944 55 of fine bars besides, from that establishment.

In calculating domestic deposits for the year 1870, a deduction is to be made (on the authority of the Alta California) of $1,274,458 Japanese gold, refined at the works alluded to, and included in the mint returns erroneously as domestic gold.

Tabular statement of gold and silver bullion deposited and parted at the United States branch mint, Carson City, Nevada, during the calendar year 1870.

Month.	Gold.		Silver.
	Deposits.	Parted from silver.	Deposits and purchases.
January	$12,600 38	$1,564 75	$3,082 76
February	4,228 00	4,738 88	3,155 99
March	30,499 73	1,931 86	6,070 30
April	20,446 18	2,615 83	2,173 40
May	17,897 97	12,984 29	5,716 58
June	14,623 98	22 59	8,063 13
July	11,654 29	486 31	6,427 72
August	4,884 09	9,065 65	1,974 66
September	5,310 18	1,741 00	820 16
October	6,554 45	1,213 73	1,421 44
November	3,840 04	6,239 49	2,217 65
December	15,536 76	22,451 16	16,095 75
Total	148,076 05	65,055 54	57,219 54

RECAPITULATION.

	Gold.	Silver.
Amount of deposits	$148,076 05	$57,219 54
Amount parted from silver	65,055,54	
Total	213,131 59	57,218 54
Total amount of gold and silver		$270,351 13

Statement showing number of pieces coined of each denomination at the United States branch mint, Carson City, Nevada, during the calendar year 1870.

Month.	Denomination and number of pieces coined—Gold.			Value.
	Double eagle.	Eagle.	Half eagle.	
February		1,644		$16,440 00
March	1,332		400	28,640 00
April	398	795	760	19,710 00
May	1,137	204	730	28,430 00
June	462	805		17,290 00
July			2,530	12,650 00
August	460	1,300		22,200 00
September		440	530	7,050 00
October			725	3,625 00
November		720		7,200 00
December			2,000	10,000 00
February (gold bar)	1			66 05
Total	3,790	5,908	7,675	173,301 05

Statement showing number of pieces coined, of each denomination, at the United States branch mint, Carson City, Nevada, during the calendar year 1870.

Month.	Denomination and number of pieces coined—Silver.			Value.
	Dollar.	Half dollar.	Quarter dollar.	
February	3,747			$3,747 00
March	4,491			4,491 00
April	500	2,000	3,540	2,385 00
May	600	5,500	1,400	3,700 00
June	2,820	5,300		5,470 00
July		22,887		11,443 50
August	304	5,800	3,400	4,054 00
September		1,650		825 00
October		1,680		840 00
November		3,100		1,550 00
December		6,700		3,350 00
Total	12,462	54,617	8,340	41,855 50

RECAPITULATION.

No. pieces gold.	Value.	No. pieces silver.	Value.	Total No. pieces.	Value.
17,373	$173,301 05	75,419	$41,855 50	92,792	$215,156 55

Deposits of gold and silver bullion at the United States branch mint at Denver for the calendar years 1867, 1868, 1869, *and* 1870.

Year.	Deposits of gold bullion.	Deposits of silver bullion.	Unparted bars returned to depositors.	Unparted bars sent to U. S. Mint, Philadelphia.
1867	$245,143 76		$243,918 11	$1,225 65
1868	555,696 56		554,126 21	1,570 35
1869	1,074,887 21	$19,185 43	1,091,337 52	2,735 12
1870	967,731 12		966,168 92	1,562 20
Total	2,843,458 65	19,185 43	2,855,550 76	7,093 32

Deposits of gold and silver bullion at United States assay office, New York.

Date.	Description.	Value.	Total value.
	GOLD.		
1868	United States bullion	$7,500,026 30	
	Foreign bullion	472,983 90	
	Jewelers' bars	294,432 32	
			$8,267,442 52
1869	United States bullion	7,324,267 91	
	Foreign bullion	429,404 11	
	Jewelers' bars	396,641 82	
			8,150,313 84
1870	United States bullion	4,722,739 51	
	Foreign bullion	558,071 20	
	Jewelers' bars	378,469 40	
			5,659,280 11
	SILVER.		
1868	United States bullion	499,401 66	
	Foreign bullion	165,986 89	
	Jewelers' bars	121,975 77	
			787,364 32
1869	United States bullion	832,249 25	
	Foreign bullion	410,540 56	
	Jewelers' bars	155,601 49	
			1,398,391 30
1870	United States bullion	916,456 84	
	Foreign bullion	485,813 09	
	Jewelers' bars	141,640 19	
			1,543,910 12

OPERATIONS OF THE UNITED STATES ASSAY OFFICE IN NEW YORK.

Statement exhibiting quarterly the amount of bullion deposits, the amount of silver parted from gold, and the amount of fine silver and fine gold bars manufactured at the United States assay office in New York, from the year 1861 *to the close of the year* 1870, *both inclusive.**

	Bullion deposits.		Silver parted from gold.	Fine silver bars manufactured.	Fine gold bars manufactured.
	Gold.	Silver.			
1861.					
1st quarter	$17, 882, 426	$452, 118	$70, 275	$50, 318	$8, 376, 175
2d quarter	21, 959, 126	792, 647	81, 729	19, 550	5, 170, 319
3d quarter	16, 192, 742	880, 103	52, 246	124, 593	6, 710, 462
4th quarter	7, 025, 893	289, 486	54, 984	194, 720	7, 441, 739
Total, 1861	63, 060, 187	2, 414, 354	259, 234	389, 181	27, 698, 695
1862.					
1st quarter	$1, 200, 910	$85, 611	$12, 161	$62, 573	$1, 584, 361
2d quarter	275, 368	55, 590	4, 570	33, 716	358, 207
3d quarter	667, 337	71, 732	8, 944	43, 085	640, 451
4th quarter	404, 747	78, 066	6, 787	52, 313	427, 838
Total, 1862	2, 548, 362	290, 999	32, 462	191, 687	3, 010, 857
1863.					
1st quarter	$382, 258	$55, 487	$6, 540	$26, 251	$388, 616
2d quarter	357, 765	75, 679	5, 993	36, 894	336, 934
3d quarter	268, 148	66, 251	4, 478	58, 722	311, 978
4th quarter	441, 551	64, 876	5, 771	39, 822	377, 817
Total, 1863	1, 449, 722	262, 293	22, 782	161, 689	1, 415, 345
1864.					
quarter	$461, 581	$68, 653	$6, 908	$43, 796	$437, 379
quarter	413, 545	54, 159	5, 851	30, 968	412, 578
3d quarter	660, 763	55, 920	8, 893	27, 604	571, 560
4th quarter	1, 505, 142	48, 828	18, 735	29, 733	[illegible], 358, 504
Total, 1864	3, 041, 031	227, 560	40, 387	132, 101	2, 779, 961
1865.					
1st quarter	$2, 086, 868	$62, 313	$21, 881	$35, 184	$1, 787, 006
2d quarter	997, 488	76, 581	10, 925	55, 965	1, 230, 798
3d quarter	1, 755, 193	187, 077	17, 238	99, 253	1, 768, 355
4th quarter	2, 202, 900	82, 137	23, 693	146, 910	2, 279, 392
Total, 1865	7, 042, 449	408, 108	73, 737	337, 312	7, 065, 551
1866.					
1st quarter	$2, 676, 657	$150, 754	$27, 035	$78, 987	$2, 076, 140
2d quarter	2, 441, 673	122, 608	24, 132	93, 202	2, 738, 564
3d quarter	4, 946, 751	158, 970	43, 766	84, 096	3, 416, 819
4th quarter	4, 321, 608	86, 631	44, 402	151, 948	5, 599, 944
Total, 1866	14, 386, 689	518, 963	139, 335	408, 233	13, 831, 467
1867.					
1st quarter	$1, 610, 382	$125, 392	$16, 898	$64, 870	$1, 273, 104
2d quarter	906, 886	134, 479	9, 810	124, 241	910, 875
3d quarter	1, 838, 111	101, 665	16, 881	82, 214	1, 466, 364
4th quarter	1, 712, 448	115, 725	19, 861	168, 716	1, 988, 992
Total, 1867	6, 067, 827	477, 261	63, 450	440, 041	5, 639, 335
1868.					
1st quarter	$1, 014, 216	$134, 562	$13, 050	$96, 155	$1, 025, 552
2d quarter	1, 527, 577	180, 455	17, 987	102, 420	1, 086, 175
3d quarter	3, 674, 123	154, 057	37, 728	187, 570	3, 205, 003
4th quarter	2, 051, 526	218, 412	24, 162	216, 369	2, 858, 993
Total, 1868	8, 267, 442	687, 486	92, 867	602, 514	8, 175, 723
1869.					
1st quarter	$1, 317, 619	$157, 831	$18, 030	$52, 375	$873, 807
2d quarter	2, 221, 900	198, 552	26, 052	185, 787	2, 284, 112
3d quarter	2, 902, 350	335, 223	31, 652	119, 608	1, 728, 323
4th quarter	1, 708, 444	430, 732	22, 313	243, 053	2, 669, 233
Total, 1869	8, 150, 313	1, 122, 338	98, 047	600, 823	7, 553, 475

Statement exhibiting quarterly the amount of bullion deposits, &c—Continued.

	Bullion deposits.		Silver parted from gold.	Fine silver bars manufactured.	Fine gold bars manufactured.
	Gold.	Silver.			
1870.					
1st quarter	$1, 007, 257	$346, 546	$14, 817	$185, 453	$1, 188, 142
2d quarter	1, 039, 841	236, 811	14, 764	159, 286	1, 070, 570
3d quarter	1, 678, 655	254, 088	18, 067	222, 413	1, 423, 939
4th quarter	1, 933, 527	618, 525	23, 895	350, 230	1, 890, 468
Total, 1870	5, 659, 280	1, 455, 970	71, 543	917, 382	5, 573, 119

*Prepared by J. M. Floyd, esq., accountant, New York assay office.

Recapitulation from the organization of the assay office, October 10, 1854, *to April* 1, 1871, *a period of sixteen years and six months.*

	Bullion deposits.		Silver parted from gold.	Fine silver bars manufactured.	Fine gold bars manufactured.
	Gold.	Silver.			
1854	$9, 260, 893	$76, 306	$67, 560	$2, 051	$2, 888, 059
1855	26, 688, 350	350, 146	195, 241	118, 562	20, 441, 814
1856	17, 803, 692	458, 725	134, 610	466, 438	19, 396, 046
1857	21, 760, 237	2, 015, 405	167, 308	180, 218	21, 691, 112
1858	19, 301, 911	2, 275, 980	167, 422	232, 161	19, 125, 484
1859	4, 441, 539	569, 816	48, 160	277, 558	4, 580, 732
1860	16, 942, 272	536, 163	107, 309	253, 741	11, 276, 419
1861	63, 060, 187	2, 414, 354	259, 234	389, 181	27, 698, 695
1862	2, 548, 362	290, 999	32, 462	191, 687	3, 010, 857
1863	1, 449, 722	262, 293	22, 782	161, 689	1, 415, 345
1864	3, 041, 031	227, 560	40, 387	132, 101	2, 779, 961
1865	7, 042, 449	408, 108	73, 737	337, 312	7, 065, 551
1866	14, 386, 689	518, 963	139, 335	408, 233	13, 831, 467
1867	6, 067, 827	477, 261	63, 450	440, 041	5, 639, 335
1868	8, 267, 442	687, 486	92, 867	602, 514	8, 175, 723
1869	8, 150, 313	1, 122, 338	98, 047	600, 823	7, 555, 475
1870	5, 659, 280	1, 455, 970	71, 543	917, 382	5, 573, 119
1871, 1st quarter	1, 195, 661	560, 708	15, 695	303, 335	744, 267
Total	237, 067, 866	14, 708, 581	1, 797, 155	6, 015, 227	182, 889, 461

Bullion transmitted from the assay office, in New York, to United States Mint, Philadelphia, for coinage, from October 10, 1854, *to January* 1, 1871.

	Gold.	Silver.		Gold.	Silver.
1854, 4th quarter	$5, 142, 202	$41, 417	1864	$1, 398, 941	$120, 650
1855	7, 722, 477	71, 588	1865	4, 515, 634	205, 815
1856	5, 797, 652	412, 416	1866	10, 758, 453	335, 141
1857	9, 307, 929	1, 887, 548	1867	3, 038, 773	158, 967
1858	3, 304, 179	2, 186, 141	1868	476, 903	310, 766
1859	395, 610	426, 374	1869	1, 229, 448	787, 219
1860	11, 854, 834	278, 197	1870	2, 143, 495	721, 348
1861	62, 480, 508	2, 663, 046			
1862	1, 344, 476	245, 977	Total	131, 519, 825	11, 006, 636
1863	608, 311	154, 004			

Cost of transportation: For gold, at $1 per M., $131,519; silver, at $3 per M., $33,018.

BRANCH MINT AT CHARLOTTE, NORTH CAROLINA.

The operations of this establishment during the year 1870 amounted to $14,224 34, bullion assayed and returned to depositors in the form of stamped (unparted) bars. This is an increase of about 30 per cent. on the increase of the preceding calendar year.

In obtaining from the foregoing tables an approximate estimate of the amount of domestic gold and silver deposited for coinage in each calendar year, the most reasonable course is to add the total deposits at San Francisco and Carson City to the deposits of United States bullion at Philadelphia, since at the first two establishments all domestic deposits are actually turned into coin, (with slight exceptions,) and at the latter establishment it involves less error to assume that all the domestic deposits are coined than to assume that all the foreign and jewelers' deposits are coined. In this way I obtain—

Total coinage of domestic gold and silver.

1867	$24, 126, 023
1868	19, 432, 339
1869	19, 464, 346*
1870	23, 003, 650†

From the monthly reports of the Bureau of Statistics of the Treasury Department I have compiled the following—

Tabular statement of exports, imports, and reëxports of gold and silver coin and bullion for the calendar years 1867, 1868, 1869, *and* 1870.

IMPORTS.

Year ending December 31—	Bullion.			Coin.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
1867	$1, 343, 259	$61, 074	$1, 406, 333	$5, 082, 915	$4, 619, 100	$9, 702, 015
1868	1, 174, 570	115, 520	1, 290, 090	7, 541, 239	4, 863, 609	12, 404, 848
1869	* 751, 821	97, 829	849, 650	15, 829, 763	8, 289, 114	24, 118, 877
1870	833, 689	127, 928	961, 617	9, 596, 872	15, 014, 874	24, 611, 746
Total for four years	4, 105, 330	402, 351	4, 507, 690	38, 050, 789	32, 786, 697	70, 837, 486

* Given as $3,168,610, by a clerical error, in No. 6, series 1869–'70, of the Bureau of Commerce and Navigation, but corrected in No. 6, series 1870–'71.

EXPORTS.

Year ending December 31—	Bullion.			Coin.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
1867	$19, 192, 299	$15, 503, 527	$34, 695, 826	$30, 839, 898	$1, 919, 368	$32, 759, 266
1868	17, 402, 625	13, 987, 210	31, 389, 835	38, 328, 530	2, 012, 716	40, 341, 246
1869	13, 681, 984	12, 748, 315	26, 430, 299	12, 938, 834	1, 668, 304	14, 607, 138
1870	15, 599, 880	13, 171, 419	28, 771, 299	33, 101, 931	4, 224, 087	37, 326, 018
Total for four years	65, 876, 788	55, 410, 471	121, 287, 259	115, 033, 668	9, 824, 475	125, 033, 668

REËXPORTS.

Year ending December 31—	Bullion.			Coin.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
1867	$60, 641	$251, 924	$312, 565	$2, 836, 698	$4, 989, 243	$7, 825, 941
1868	50, 871	635, 339	686, 210	4, 150, 810	4, 591, 483	8, 742, 293
1869	16, 142	15, 206	31, 348	7, 934, 976	8, 352, 250	16, 287, 226
1870	25, 778	2, 682	28, 460	4, 689, 722	10, 136, 226	14, 825, 948
Total for four years	153, 432	905, 151	1, 058, 583	19, 612, 206	28, 069, 202	47, 681, 408

* The silver coinage at Philadelphia in 1869 and 1870 being less than the domestic deposits, the amount of coinage is taken instead of the latter.

† Deducting $1,274,458 Japanese gold, deposited as domestic bars at San Francisco.

Combining these tables of coinage and exports, we obtain—

Table of coinage and export of domestic gold and silver for the calendar years 1867, 1868, 1869, *and* 1870.

Year.	Coinage.	Export.	Total.
1867	$24,126,023	$34,695,826	$58,821,849
1868	19,432,339	31,389,835	50,822,174
1869	19,464,346	26,430,299	45,894,645
1870	23,003,650	28,771,299	51,774,949

Whoever chooses to accept these totals as fairly representing the production of the country may do so; for my part, I cannot regard them as complete. I have already shown the impracticability of obtaining from the mint returns a correct account of the domestic gold and silver turned into coinage, (though a recent writer avers that this item is furnished by the reports of the Director "with absolute accuracy!"); and it may be added that there is grave reason to doubt the figures given for exports. In addition to private information received on this point from the Statistical Bureau, and conclusions drawn from personal inquiry into the manner of making up these figures, I may refer to the annual report of the Director of the Bureau of Statistics, dated November, 1867, where it is shown that the law under which the statistics of export are obtained refers to vessels only, and therefore takes no account of overland exports. In the year ending June 30, 1867, $6,211,752 in treasure was exported overland to Canada alone. Of course this was mostly coin, yet a part was undoubtedly in bars, and it must be remembered that this item (taken from Canadian tables and not found in our own) does not include any other of the then separate British Provinces; nor is there any record of the exports into Mexico, although the large amount of commerce carried on through the "free zone" must involve some movement of treasure.

Again, the Director says: "It will be observed that, although collectors of customs are forbidden to grant a clearance for any vessel bound to a foreign place unless full manifests of the cargo are previously furnished, there is no penalty in case a vessel obtains a clearance and departs without giving a full manifest. A comparison of our exports with the imports officially reported by the principal countries with which we trade, and a detailed examination of the export manifests at some of our large ports, established the fact that this is not unfrequently the case."

The British commissioners of customs remark, in a report upon this subject: "Exporters often endeavor, and not unfrequently with success, to ship their goods without clearance, in order to avoid the knowledge of their transactions which might be obtained through the bill of entry office." This motive has acted with greater force during the last seven years in the case of gold and silver than in that of any other commodities. The speculation in these two articles has been intense, continuous, and full of rapid fluctuations beyond all previous precedents. There has been the strongest possible inducement to conceal the true amounts of specie and bullion exported, and the weakest possible means of preventing such concealment. Finally, stories of surreptitious shipments are current in Wall street.

On the other hand, it is equally desirable sometimes, for purposes of speculation, to overrate the exports of treasure; although it seems less easy of performance, except by actual false swearing. I have attempted to compare our export statistics with those of the imports of some for-

eign countries, but without much success. I introduce here a single instance. The following tables are furnished at my request by Mr. E. B. Elliott, chief clerk of the Bureau of Statistics at Washington:

Exports of gold and silver coin and bullion from the United States, 1867 *to* 1870, *fiscal years ended June* 30.

Year.	Gold coin.	Gold bullion.	Silver coin.	Silver bullion.
1867	$22, 363, 635	$13, 867, 641	$2, 892, 990	$15, 853, 530
1868	44, 390, 003	23, 841, 155	2, 536, 506	12, 978, 311
1869	14, 858, 369	13, 584, 407	899, 763	13, 573, 427
1870	12, 768, 501	15, 812, 108	3, 554, 329	11, 748, 864
Total	94, 379, 508	67, 105, 311	9, 883, 588	54, 154, 132
Proportion of above exported to Great Britain.				
1867	$13, 828, 232	$6, 427, 475	$953, 460	$6, 101, 426
1868	27, 514, 387	9, 846, 629	984, 949	4, 654, 712
1869	7, 587, 494	6, 372, 734	32, 006	5, 201, 960
1870	5, 454, 963	10, 518, 704	80, 000	8, 129, 286
Total	54, 385, 076	33, 165, 542	2, 050, 415	24, 087, 384

Imports of gold and silver coin and bullion into Great Britain, 1867 *to* 1870, (*calendar years.*)

	Year.	Total imports.		Imp'ts from United States.	
		Quantities.	Value.	Quantities.	Value.
		Ounces.	£	*Ounces.*	£
1.—British gold coin	1867	534, 298	2, 080, 421	20, 596	....
	1868	354, 387	1, 379, 893	24, 857	....
	1869	658, 500	2, 564, 032	79, 828	....
2.—Foreign gold coin	1867	1, 373, 528	5, 226, 100	1, 034, 757	....
	1868	1, 617, 534	6, 159, 494	1, 392, 997	....
	1869	519, 096	1, 974, 987	292, 322	....
3.—Gold bullion	1867	2, 130, 514	8, 493, 638	266, 790	....
	1868	2, 371, 453	9, 596, 790	418, 293	....
	1869	2, 282, 169	9, 231, 793	107, 546	....
4.—Total gold	1867	4, 038, 340	15, 800, 159	1, 322, 143	5, 026, 185
	1868	4, 343, 376	17, 136, 177	1, 836, 147	6, 976, 455
	1869	3, 459, 765	13, 770, 812	479, 696	1, 828, 694
5.—British silver coin	1867	332, 744	83, 949	74, 118	....
	1868	332, 424	83, 780	8, 400	....
	1869	216, 766	54, 577	8, 000	....
6.—Foreign silver coin	1867	20, 689, 680	5, 087, 548	2, 150, 683	....
	1868	19, 520, 588	4, 752, 926	2, 211, 316	....
	1869	14, 332, 716	3, 540, 863	2, 994, 807	....
7.—Silver bullion	1867	11, 207, 976	2, 849, 391	3, 649, 752	....
	1868	11, 330, 005	2, 879, 712	5, 400, 694	....
	1869	12, 341, 221	3, 134, 739	1, 480, 055	....
8.—Total silver	1867	32, 230, 400	8, 020, 888	5, 874, 553	1, 471, 821
	1868	31, 183, 017	7, 716, 418	7, 620, 410	1, 915, 939
	1869	26, 890, 703	6, 730, 179	4, 482, 862	1, 109, 739

As the returns from Great Britain are those of calendar years, while those of the United States are of fiscal years, a direct comparison is impossible; but an approximation may be arrived at in the following manner: Deducting from the exports of gold bullion to Great Britain for the fiscal years 1867, 1868, 1869, and 1870, half of the first and half of the last item, we have $24,692,453 as the probable exports for the calendar years 1867, 1868, and 1869. This is confirmed by the following proportion: $67,105,311 (total exports of gold bullion for the fiscal years 1867, 1868, 1869, and 1870): $50,276,908 (total ditto for the calendar years 1867, 1868, and 1869, as per a previous table) :: $33,155,542, (exports of gold bullion to Great Britain for the four fiscal years,) ditto

for the three calendar years. The result corresponds within about $100,000. A similar computation gives for the silver bullion exported to Great Britain during the calendar years 1867, 1868, and 1869, by the method of deduction, $16,972,028, and by the method of proportion, about $18,750,000; the mean of the two determinations being about $17,860,000.

The British tables show 3,637,986 ounces of gold coin and bullion, with an aggregate value of £13,831,334 imported from the United States during the same period. To get at the value of the bullion separately, I have deducted that of 125,281 ounces British coin, at the rates given in the mint tables, amounting to £488,995, and that of the foreign coin, £10,433,410, leaving £2,908,929 as the value of 792,629 ounces of gold bullion imported from the United States. This corresponds with $14,089,216, or about $17 90 per ounce. As a large proportion of the exports is in the form of unparted bars, this value is certainly high enough.

We have, then, from British sources $14,089,216, and from our own reports $24,692,453, as the export of gold bullion to Great Britain during the calendar years 1867, 1868, and 1869.

The silver values cannot be so conveniently ascertained from the data given. Yet the discrepancy between the probable value of 10,530,501 ounces reported from Great Britain, and $17,860,000 reported from the United States, is suspicious.

Having been defeated in the attempt to obtain other data for comparison, and deeming the above results a proof that the British statistics are even worse than our own, I am obliged to conclude that the information afforded from such sources is neither accurate nor susceptible of correction by analysis and comparison.

It is but fair to add that attempts have been made to secure more careful returns from collectors of ports. The following table shows the exports of gold bars from the port of New York for a little more than the calendar year 1870; unfortunately, as I am informed at Washington, other ports make no returns by this schedule:

Export of gold bars from the port of New York.

For the five weeks ending September 25, 1869	$81,273
For the eleven weeks ending December 11, 1869	604,215
For the six weeks ending January 22, 1870	313,468
For the five weeks ending February 26, 1870	294,586
For the three weeks ending March 19, 1870	89,267
For the three weeks ending April 9, 1870	19,928
For the three weeks ending April 30, 1870	183,822
For the four weeks ending May 28, 1870	2,289,943
For the four weeks ending June 25, 1870	2,854,932
For the four weeks ending July 23, 1870	1,098,151
For the four weeks ending August 20, 1870	860,408
For the four weeks ending September 17, 1870	1,036,909
For the four weeks ending October 15, 1870	499,879
For the five weeks ending November 19, 1870	152,000
For the five weeks ending December 24, 1870	249,284
For the four weeks ending January 22, 1871	241,368
	10,869,433

Having said thus much as to the imperfection of the data afforded by the reports of the Mint and the custom-house for ascertaining the amounts of domestic coinage and exports of gold and silver, I will add a few words, setting forth my general objection to the theory that these

amounts, if correctly ascertained, would give the aggregate annual product of the country. The article above quoted from the Alta California recognizes the fact that amounts of bullion *in transitu*, or in the hands of dealers at the end of the year, are not included in this method of calculating the product. But this is a small matter compared with the omission of sundry items, which are not made good, as is the one alluded to by subsequent reports.

In the first place no account is taken of the gold and silver exported in the form of ores and mattes. I have direct information of more than a million dollars in value thus exported during 1870. Yet the item appears neither in the merchandise nor in the treasure reports of the custom-house. Perhaps it is believed, to use the phrase of the Alta, that gold and silver shipped in ballast do not "affect the markets of the world." As my duty, however, does not concern the markets of the world, but the actual results of American industry, I think this item worthy of notice.

Another instance in point is the amount of gold dust annually lost by its use as currency. This practice has almost ceased, save in a few of our productive placer districts, where several million dollars are still annually passed from hand to hand in trade. I estimate the quantity produced and lost in this way during 1870 at $100,000.

Again, in several Western States and Territories there is a considerable local manufacture of jewelry from gold dust, without further preparation than that which the manufacturers give it. The small town of Helena, Montana, contains five establishments, some of which employ a considerable number of workmen, and all of which manufacture jewelry from native gold alone. A large amount of gold is annually hoarded, moreover, in the form of specimens. In one or two instances, the superintendents of mines have adopted the practice of selling specimens; and the amounts realized from such sales indicate a larger consumption in this direction than most persons would imagine. It is safe to say that $400,000 annually are worked up by local jewelers or hoarded as specimens.

But a far more important matter than any of these is the annual consumption of gold and silver by the manufacturing jewelers, watch-case, gold pen, and spectacle makers, dentists, and silver-platers of the country. Those who think they can obtain the aggregate product of the precious metals by adding domestic coinage and domestic bullion exports assume that all our gold and silver is either coined or exported, and that all the domestic gold and silver used in manufactures has been previously recorded under one of these heads. This very convenient assumption is totally untrue. Our manufacturing jewelers do not, as a rule, melt coin at all. They either buy mint bars, or they purchase gold prepared for their special uses, in bars, plate, wire, foil, etc., from parties who make a business of this part of the work.

These gold-preparing houses, of which there are several in the city of New York, take a large amount of fine bars from the Mint and assay offices; but they also refine gold for themselves before alloying it for the manufacturers. Their deposits at the New York assay office include foreign, worn and mutilated coin, unparted bars, and gold dust. The quantity which they refine for themselves it is impossible for me to state. Perhaps the manufacturing blanks of the census, when published, will throw some light on this point. At the present stage of the work in the Census Bureau no information regarding it is available.

Estimates as to the amount of gold consumed by jewelers, etc., vary considerably. The lowest I have obtained from those engaged in the business is $9,000,000 annually; the highest is over $13,000,000. That

this is mainly in mint and other bars, and not in coin, I am thoroughly satisfied by repeated inquiries of the trade.

It is equally certain that the silversmiths melt up large quantities of fine bars as well as coin, and that the silver-platers use silver bars to a great extent.

It is therefore undeniable that the assumption that the fine bars produced at the Mint and not coined are all exported is a great mistake. A large portion of these bars is consumed in this country by manufacturers, together with a still larger amount of other bars which never saw the Mint at all.

In conclusion, my estimates of production for 1870 amount to $66,000,000; of this $51,774,949 is accounted for by the Mint and export returns; but these returns are themselves imperfect, and if they were absolutely accurate, they are still inadequate to the case. The difference of $14,225,051 results from, 1, the errors of my estimates; 2, the errors of the calculated coinage and exports; 3, the amount of gold and silver reported as in ores and mattes, consumed in the mining districts, etc.; 4, the amount of domestic gold and silver, not coin, consumed in manufactures. It is scarcely profitable to discuss further a problem the elements of which are so imperfectly known. But so long as the production of gold and silver in the country is so difficult to ascertain by tracing its movements and final destinations, I cannot but think it my duty to furnish independent data from other sources. If the aggregates thus obtained show a remarkable excess over those otherwise obtained, the fact is one to be noted and studied, not obliterated by a cowardly alteration of one set of figures to suit the other set. For five years the estimates of the Commissioners of Mining Statistics have thus exceeded, by a nearly constant amount, the totals furnished by the Mint and custom-house. It is easy to sneer at the Commissioners as "statistical neophytes;" but it would be wiser for the statistical veterans to suspect their data and methods, and rise for once from the study of conventional figures to the contemplation of facts.

APPENDIX.

RECEIPTS OF TREASURE AT SAN FRANCISCO.

[From the Commercial Herald, January 13, 1871.]

The following table comprises the receipts of treasure in this city, through Wells, Fargo & Co.'s Express, during the year 1870:

From the northern and southern mines.

	Silver bullion.	Gold dust.	Coin.	Totals.
1870.				
January	$1,116,129	$1,109,122	$683,649	$2,908,800
February	1,034,472	1,060,827	384,223	2,479,522
March	978,548	1,465,574	601,842	3,045,964
April	1,047,276	1,511,802	524,814	3,083,892
May	1,200,171	1,815,647	398,289	3,414,107
June	1,391,142	1,855,753	414,184	3,661,079
July	1,200,515	1,651,430	442,891	3,294,836
August	1,198,144	1,680,800	693,656	3,572,600
September	1,314,727	1,689,694	656,675	3,661,096
October	1,034,513	1,304,219	504,037	2,842,769
November	1,434,803	1,422,300	562,312	3,419,515
December	1,202,544	1,194,963	620,465	3,017,972
Total 1870	14,152,984	17,762,131	6,487,037	38,402,152
Total 1869	Not sep'td.	Not sep'td.	11,572,594	44,045,445
Total 1868	Not sep'td.	Not sep'td.	6,620,297	45,932,940
Total 1867	Not sep'td.	Not sep'td.	4,812,787	45,404,770

From the northern coast.

	Silver bullion.	Gold dust.	Coin.	Totals.
1870.				
January	....	$302,429	$48,038	$350,467
February	....	201,662	33,530	235,192
March	....	88,082	70,866	158,948
April	....	195,806	35,494	231,300
May	....	67,533	59,867	127,400
June	....	340,902	24,260	365,162
July	....	313,200	14,685	327,885
August	....	513,269	46,793	560,062
September	....	526,405	25,095	551,500
October	....	300,490	18,410	318,900
November	....	324,150	16,521	340,671
December	....	206,638	139,342	345,980
Total 1870	....	3,380,566	532,901	3,913,467
Total 1869	Not sep'td.	Not sep'td.	300,397	2,958,458
Total 1868	Not sep'td.	Not sep'td.	728,851	2,936,955
Total 1867	Not sep'td.	Not sep'td.	1,396,439	3,801,489

From the southern coast.

	Silver bullion.	Gold dust.	Coin.	Totals.
1870.				
January	....	$7,930	$168,462	$176,392
February	....	13,725	73,430	87,155
March	....	30,305	64,019	94,324
April	....	13,472	81,601	95,073
May	....	186,548	30,014	216,562
June	....	11,339	95,410	106,749
July	....	9,280	85,430	94,710
August	....	10,697	62,845	73,542
September	....	21,314	50,256	71,570
October	....	21,747	49,508	71,255
November	....	42,532	37,674	80,206
December	....	30,999	45,899	76,898
Total 1870	....	399,888	844,548	1,244,436
Total 1869	Not sep'td.	Not sep'td.	227,000	2,282,571
Total 1868	Not sep'td.	Not sep'td.	557,050	2,304,060
Total 1867	Not sep'td.	Not sep'td.	1,096,440	2,391,341

CURRENCY MOVEMENT.

The annexed table exhibits the interior and coastwise receipts, (Wells, Fargo & Co.,) imports foreign, and exports for the year 1868, 1869, and 1870:

	1868.	1869.	1870.
Interior receipts	$51,173,955	$49,286,474	$42,874,746
Imports, foreign	3,336,280	6,023,677	5,466,883
Total	54,510,235	55,310,151	48,341,629
Exports	35,444,395	37,287,117	32,983,140
Currency movement	19,065,840	18,023,034	15,358,489

TREASURE PRODUCT, IMPORTS, ETC.

The receipts of treasure from all sources, through regular public channels, during the past twelve months, as compared with the same period in 1869, have been as follows:

	1869.	1870.
From northern and southern mines	$44,045,445	$38,402,152
Coastwise, north and south	5,241,029	4,472,594
Imports, foreign	6,023,677	5,466,883
Totals	55,310,151	48,341,629

The following table shows the value and destination of treasure shipments from this port during the past sixteen years, from 1855 to 1870, inclusive:

Years.	Eastern ports.	England.	China.	Panama.	Other ports.	Totals.
1855	$38,730,564	$5,182,156	$889,675	$231,207	$128,129	$45,161,731
1856	39,895,294	8,666,289	1,308,852	253,268	573,732	50,697,434
1857	35,531,778	9,347,743	2,993,264	410,929	692,978	48,976,692
1858	35,891,236	9,265,739	1,916,007	299,265	175,779	47,548,026
1859	40,146,437	3,910,930	3,100,756	279,949	202,390	47,640,462
1860	35,719,296	2,672,936	3,374,680	300,819	258,185	42,325,916
1861	32,628,011	4,061,779	3,541,279	349,769	95,920	40,676,758
1862	26,194,035	12,950,140	2,660,754	434,508	322,324	42,561,761
1863	10,389,330	28,467,256	4,206,370	2,503,296	505,667	46,071,920
1864	13,316,122	34,436,423	7,888,973	378,795	686,888	56,707,201
1865	20,583,390	15,432,639	6,963,522	1,224,845	1,103,832	45,308,227
1866	29,244,891	6,532,208	6,527,287	511,550	1,548,457	44,364,393
1867	23,355,903	5,841,184	9,031,504	372,552	3,075,149	41,676,722
1868	21,468,800	5,312,979	6,193,995	640,000	1,828,621	35,444,395
1869	12,459,813	11,841,812	6,487,445	658,182	5,839,865	37,287,117
1870	13,443,295	9,790,631	5,496,856	255,497	3,996,861	32,983,140
Totals	428,998,195	173,712,844	72,581,219	9,104,431	21,034,776	705,431,895

It will be seen that our treasure exports to eastern ports were $983,482 more than in 1869, while those to England decreased $2,051,181; also to China and Panama, $1,393,274; to other ports, $1,843,004.

EXPORTS OF GOLD AND SILVER BARS FROM SAN FRANCISCO.

[From the Alta California.]

	Gold.	Silver.
1866	$24,995,524	$12,985,150
1867	19,689,943	15,228,260
1868	17,595,831	13,902,093
1869	13,610,466	11,599,794
1870	8,962,148	11,672,391

PRODUCT OF QUICKSILVER.

[From the San Francisco Commercial Herald, January 13, 1871.]

	1868.	1869.	1870.
	Flasks.	*Flasks.*	*Flasks.*
New Almaden Mine	25,600	17,000	14,000
New Idria Mine	12,300	10,450	10,000
Redington Mine	8,700	5,000	4,546
Sundry other mines	2,100	1,150	1,000
Total	48,700	33,600	29,546

The exports east and to different countries for 1867, 1868, 1869, and 1870, were as follows:

	1867.	1868.	1869.	1870.
	Flasks.	*Flasks.*	*Flasks.*	*Flasks.*
New York	2,900	4,500	1,500	1,000
Great Britain	1,500	3,500	....	....
China	10,011	17,785	11,600	4,050
Mexico	10,042	14,120	8,060	7,088
South America	3,800	2,500	2,900	1,300
Australia	300	1,580	300	300
British Columbia	20	20	4	9
Other countries	280	501	51	41
Total	28,853	44,506	24,415	13,788

The exports of former years were—

Year.	Flasks.	Year.	Flasks.
In 1852	900	In 1860	9,448
In 1853	12,737	In 1861	35,995
In 1854	20,963	In 1862	33,747
In 1855	27,165	In 1863	26,014
In 1856	23,740	In 1864	36,927
In 1857	27,262	In 1865	42,469
In 1858	24,142	In 1866	30,287
In 1859	3,399		

These tables show the production from all the mines on the Pacific slope to be, in 1870, about 4,000 flasks less than in 1869, while the exports have been 10,627 flasks less in 1870 than in the year preceding. The price a year ago was 60 cents, against 90 cents at this date. The product of the Redington Quicksilver Mine for the year 1870 has been 4,546 flasks, the company having used only one-half of their reduction capacity. It is understood that the company is under contract for all the quicksilver they produce up to April, 1872, at $40 per flask, and although this figure undoubtedly affords them a handsome profit, it is not difficult to see how, in view of the great advance in quicksilver, (now selling at 90 cents per pound, or $68 85 per flask,) they should prefer to produce, during the remainder of the contract, only the half of their known capacity, choosing rather to keep in their mine the rich bodies of ore which they have recently discovered, to be worked after the expiration of their contract, when it will yield them at least 50 per cent. more than if brought to market now. This policy may operate rather severely on consumers, by contributing to enhance the price of quicksilver, but it cannot be denied that it is a very natural one for the company to pursue under the peculiar existing circumstances. The local sale of quicksilver for consumption on this coast has been, in 1870, 30 per cent. greater than in 1869, showing a noteworthy increase, in spite of the largely advanced price.

MONTHLY RECEIPTS OF COAL AT SAN FRANCISCO FROM MONTE DIABLO.

[From the Alta California January, 6, 1871.]

	Tons.		Tons.
January	11,174	September	11,654
February	10,917	October	12,186
March	12,205	November	10,178
April	10,137	December	11,161
May	11,046		
June	10,310	Total for 1870	129,761
July	7,912	Total for 1869	145,227
August	10,874		

COAL TRADE OF SAN FRANCISCO.

[From the Commercial Herald.]

Imports.

	1869.	1870.
Anthracite, tons	24,844	21,320
Cumberland, tons	5,708	4,012
Cumberland, casks	11,655	6,637
English, tons	17,386	31,196

	1869.	1870.
Sydney, tons	75,145	83,982
Chili, tons	1,114	7,350
Vancouver Island	14,880	12,640
Bellingham Bay, tons	20,552	14,355
Mt. Diablo, tons	148,722	129,761
Coos Bay, tons	14,824	20,567

Specified on the way from domestic Atlantic ports.

December 31,	1869.	1870.
Tons	1,266	2,464
Casks	2,436	890

Under the general depression which has characterized our leading industries for the past year, our coal trade has maintained itself more successfully than we, perhaps, had any right to expect. In our review of the market for 1869, we noted the extraordinary import of Sydney, which set in upon us in the last quarter of that year, depressing in an unusual degree the market, both of coal and tonnage. This extraordinary import has been more than maintained during the year 1870, producing like results, even in a more marked degree. Within our recollection prices never before touched the figures which have ranged through the past year; and, as a result, importers complain of heavy losses, and ship-owners of unremunerative rates. Upon the whole, however, our domestic mines seem to have maintained themselves remarkably well. Coos Bay shows an increased production of nearly 50 per cent., and though Bellingham Bay shows a decrease of some 33 per cent., in consequence of the interruption of work at the mine incident to important improvements which were in progress, the agent assures us that the demand for this coal has been largely in excess of the supply, notwithstanding the low prices of other favorite varieties for domestic purposes. We also learn the company is now in fine working order, and expect for the future to keep the market fully supplied. Our domestic steam coals, from Mount Diablo, seem also to have maintained themselves with gratifying success. We note that the Black Diamond Company has disbursed its dividends regularly through the year, notwithstanding the depression of prices and a somewhat diminished production. The aggregate import and production for the year shows but a small apparent increase of about 2,000 tons; but, as the calorific power of our imported coals is generally estimated to be about a third greater than that of our domestic production, the excess of 26,000 tons of the former is equivalent to about 35,000 tons of the latter in actual consumption, and, therefore, more than accounts for the decrease in the production of our domestic coals for the year. It is proper to note that for the first half of the year mining operations were carried on in the Corral Hollow District, which supplied, as we learn from one of the owners, some 3,000 tons to the Western Pacific Railroad and Stockton. We have, therefore, added this amount to the total product of domestic coals, as given in our detailed tabular statement above. There has also been some coal brought from the Rocky Mountains, which is said to be a fine article for domestic purposes; but as to the amount brought, we have no figures. Classifying the various varieties as foreign, eastern, and domestic, and reducing Cumberland casks to tons at the rate of 1,600 pounds each, we submit the annexed comparative statement for the past five years:

	1866.	1867.	1868.	1869.	1870.	Totals.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Foreign	74, 500	64. 000	93, 000	109, 000	135, 168	475. 668
Eastern	22, 500	62, 500	32, 700	38, 600	30, 820	187, 120
Domestic	93, 500	124, 500	157, 000	184, 100	167, 183	726, 283
Total	190, 500	251, 000	282, 700	331, 700	333, 171	1, 389, 071

INDEX OF MINES.

A.

B.

C.

D.

F.

G.

H.

I.

L.

M.

INDEX OF COUNTIES, MINING DISTRICTS, ETC.

A.

B.

C.

M.

N.

O.

P.

INDEX OF SUBJECTS.

A.

B.

C.

Q.

R.

S.

Y.

Z.